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# Section - Technical Specifications

## Remote Terminal Units for
## Ring Main Units

# 1. Introduction

This document contains Technical Specifications that apply to: **Remote Terminal Units for Ring Main Units**, which covers supply and installation of Remote Terminal Units (RTUs) within BMAZ.

The RTUs that are to be supplied and installed in accordance with these Technical Specifications shall serve as remote DAS interfaces to switches that comprise the DAS RMUs, i.e., the circuit breakers protecting the lateral circuits fed from the RMU and load break switches connecting the RMU to its feeder main loop circuit. They shall allow the DAS to monitor & control these switches as well as monitor the information available from Fault Passage Indicators (FPIs) and Intelligent Electronic Devices (IEDs) that are a part of DAS RMUs. The IEDs include multifunction meters and feeder protection relays.

The RTUs shall interoperate with the DAS at just one of the control centres at any given time utilizing a new communications system.

## 1.1 RMU Features

The Contractor shall install the RTUs in the DAS RMU enclosures. Installation includes responsibility for connecting the RTUs to relevant RMU terminals (in the manner described elsewhere in these Technical Specifications) so that the RMUs can be monitored and controlled by the DAS. In this respect, the RTUs will also be connected to the UHF radios to be supplied and installed in the same RMU enclosures.

Key RMU components are listed as follows:

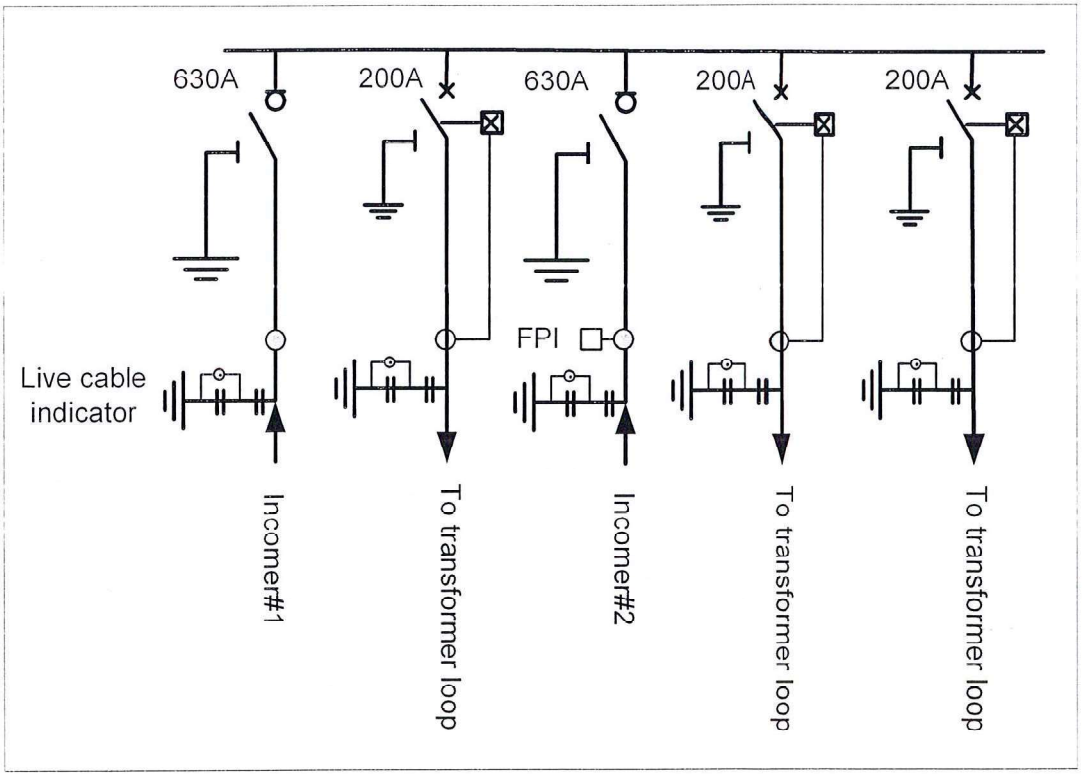
- Two (2) load break switches (LBSs) with earthing switches, also known as Operating Devices (ODs), connect the RMU to incoming and outgoing main loop, 11 kV, 630 Amp XLPE cables of size 240/400 $mm^2$ cross section aluminium conductor.
- One (1) to three (3) circuit breakers (CBs) with earthing switches, also known as Vertical Lines (VLs), connect the RMU to distribution transformer loop, 11 kV, 400 Amp XLPE cables of size 95/240 $mm^2$ cross section aluminium conductor.
- One (1) to three (3) numerical relays for overcurrent (OC) and earth fault (EF) protection in conjunction with the corresponding circuit breaker(s).
- One (1) Fault Passage Indicator (FPI) in the RMU's main loop circuit to provide indications that feeder downstream phase or earth faults have occurred.
- All necessary voltage and current sensors for metering and protection.
- All necessary dry (potential-free) contacts for indications relevant to RMU monitoring and control.
- Two (2) multifunction meters serving as Intelligent Electronic Devices (IEDs) to provide voltage, current, power, energy, and power factor readings that correspond to the RMU's main-line circuits.
- A power supply unit, including auxiliary power transformer and battery backup, to provide stable 24 VDC and 12 VDC sources of power for the RTU and radio respectively as well as necessary sources of power for the RMU's spring-charge motors, FPI, relays, and

multifunction meters. The power supply shall also provide for RMU enclosure lighting fixtures and power-plug receptacles for maintenance/test equipment.

- Capacitor voltage dividers serving live-line cable indicators.

A typical five-way RMU configuration is illustrated in Figure 1-1 below.

**Figure 1-1: Typical RMU Configuration**




## 1.2 Specification Organization

These RTU Technical Specifications are organized as follows:

- **Clause 1 - RTU Design Features.** This includes requirements covering their availability, maintainability, expandability, life span, environmental, power supply, overload, surge withstand, noise level, assembly, component identification, and interconnection features.
- **Clause 2 - RTU Characteristics.** The main characteristics are encompassed that relate to RTU functional, design, performance, equipment, enclosure, space, software/firmware, and test system features.
- **Clause 3 - RTU Inspection and Test.** This includes inspection, test procedures, test records, factory acceptance tests, and field performance test requirements for the RTUs.
- **Clause 4 - RTU Documentation.** This includes the documentation and design approval procedures and the hardware, firmware, test, and final documentation requirements.

# 2. RTU Design Features

The important RTU design features include:

- Availability, maintainability, expandability, and life span requirements
- Ability to operate in specified outdoor ambient temperature and relative humidity conditions
- Overload and surge withstand capabilities
- Noise level
- Assembly and component identification
- Interconnections
- Support facilities

In these and all other specified respects, the RTU shall meet or exceed the standards cited herein or, where appropriate, other relevant industry standards.

## 2.1 Availability, Maintainability, Expandability, and Life Span

### 2.1.1 Availability

The RTUs shall exhibit an availability of 99.9% exclusive of communication channel availability. An RTU shall be considered unavailable when:

1) Any RTU function such as monitoring or control is lost for all points of a single type
2) One input card or output card of each type fails
3) More than one input card or output card of the same type fails

### 2.1.2 Maintainability

The RTU design shall facilitate isolation and correction of all failures. The following features, which promote rapid problem isolation and replacement of failed components, shall be included:

1) Self-diagnostic capabilities within each RTU that can be initiated from the DAS
2) On-line error detection capabilities within the RTU and detailed reporting of detected errors to the DAS
3) Local indication of RTU failures.

### 2.1.3 Expandability

Each RTU shall be expandable in the field solely by card or circuit module additions (the addition of enclosures, cables, chassis, or power supplies shall not be necessary).

### 2.1.4 Life Span

Each RTU shall have a design life of at least 20 years from the date of final acceptance. The Contractor shall make available at no cost to the Employer the manufacturing designs, drawings and the rights to manufacture those subassemblies that the manufacturer will not support or discontinues to support during this life span. The specific components of each sub-assembly shall be identified and referenced in Contractor-supplied documentation.

## 2.2 Environmental Requirements

The RTUs shall be capable of operating in temperatures from 5°C to +55° C, in relative humidity values from 10 to 95% non-condensing, and at altitudes of at least 1,000 m.

## 2.3 Overload Protection

Connection of high voltage sources to input and output terminals may occur during the life of the equipment. No damage shall occur to any input or output due to continuous normal mode overload of up to 120 V (dc or peak ac), or due to imposition of up to 240 V (dc or peak ac) between any terminal and ground. Recovery from either type of overload to nominal accuracy shall require less than 5 minutes. The effect on accuracy of either type of overload on any adjacent channel shall be less than 0.1% of full scale. Input overload response characteristics shall have been tested in accordance with an applicable international standard.

Overloads greater than specified above, but less than 600 V (dc or peak ac) may damage some components, but shall not result in propagation of any damage beyond the single input, output, or communication circuit at which the overload occurred.

## 2.4 Surge Withstand Capability

The RTUs shall be able to successfully undergo the tests described in ANSI C37.90a, Guide for Surge Withstand Capability (SWC) Tests (or equivalent). Application of the SWC wave form to any input or output, including the power input and communication channel connections, shall not result in the loss of data from any input or output other than the input or output being tested. The RTU shall not reset or restart its internal logic as a result of the SWC wave form application, nor shall the contents of any internal memory be affected by the SWC testing.

## 2.5 Electrostatic and Electromagnetic Compatibility

The RTUs shall support the following requirements for electrostatic and electromagnetic compatibility for a 1 kV voltage:

1) Electrostatic Discharge: The equipment shall meet the requirements of the test in IEC 61000-4-2 Level 2.
2) Radiated Electromagnetic Field Disturbance: The equipment shall meet the requirements of IEC 61000-4-3 Level 2.
3) Conducted and Radiated Interference: The equipment shall meet the requirements of CISPR 22 Class A.
4) Surge Immunity: The equipment shall meet the requirements of IEC 61000-4-5 Level 2 for both signal and power ports.

## 2.6 Noise Level

The audible noise generated by the RTU equipment shall not exceed the values for noise criteria curve NC-45 as described in ANSI C37.1 (as extracted from MILSTD-1472) or equivalent.

## 2.7 Assembly and Component Identification

Each assembly, to the level of printed circuit cards, shall be clearly marked with the manufacturer's part number and serial number along with component revision levels. Changes to assemblies shall be indicated by an unambiguous change to the marked revision level.

All electronic parts, such as capacitors, resistors, and integrated circuits, shall be marked either with the characteristics of the part or with an industry standard part number. Where custom components are provided, such as read only memories, the component shall be marked so as to specifically identify where similar parts may be obtained.

All printed circuit card cages and all slots within the cages shall be clearly labeled. Plug-in cards or modules shall be keyed to prevent incorrect insertion or insertion into incorrect locations. Alternatively, if the design enables different types of plug-in cards to occupy any configurable slot location, no damage or malfunction shall occur if the incorrect card is plugged into a pre-configured slot, and the system shall properly identify the error.

## 2.8 Interconnecting Cables and Wiring

The Contractor shall provide all interconnecting wires, cables, connectors, terminations, and other wiring accessories required to connect the RTUs to all relevant RMU terminals. All such wiring and cabling, including wires and cables between component units of the RTU, shall be shown on Contractor-supplied drawings.

All wires and cables supplied by the Contractor shall use copper conductors and have flame retardant insulation and shall be neatly laced and clamped.

Each end of interconnection cables shall be identified by a marker, which includes the cable number, identifying number and location of each of the cable's terminations; this information shall agree with Contractor's drawings. All logic card & cable terminations shall be adequate to prevent contamination. All connection points for external cables & wires shall be easily accessible for connection and disconnection. Conductors in multi-conductor cables shall be individually color-coded.

### 2.8.1 RMU-RTU Interface Connectors

To facilitate installation and maintenance, communication port and power supply connections notwithstanding, plug-type connectors shall be used to interconnect each RTU with its associated RMU. In this respect, cabling between RMU status and control points will be brought out by the RMU supplier to a set of hooded 24-pin female connectors fixed within the RMU enclosure that will house the RTU. Consequently, to connect the RTU to the RMU, the RTU Contractor shall provide a corresponding set of hooded 24-pin male connectors wired back to the RTU via a suitable cable.

The housing containing female connectors will contain a lever capable of locking the female and male connectors together. This lever shall be fully locked only if the two connectors are correctly mated.

Each RMU whether 3-way, 4-way, 5-way, etc. will be outfitted with a set of six (6) 24-pin female connectors. In turn, therefore, the RTU supplier shall provide the corresponding set of 6 x 24-pin male connectors. These male connectors shall be wired by cable to the RTU, which in all cases shall be supplied & installed by the Contractor in a configuration sized for 5-way SCADA-ready DAS RMUs.

A possible pin-out arrangement is illustrated conceptually in Figure 2.1 below:

Terminal Blocks:

If metallic cable terminations other than those corresponding to the connectors specified, prove necessary, the Contractor shall provide heavy-duty terminal blocks with screw type terminals for 5 mm minimum machine screws. Terminals for auxiliary relays, if any, shall equal or exceed the relay wiring requirements. In using a terminal block, no more than two cables or wires shall be connected to any of its individual terminals.

Self-extinguishing fireproof vinyl marking strips shall be used to identify all external connection blocks. Marking tags shall be read horizontally. All terminals to which battery or other high voltages are connected shall be provided with fireproof covers.

If relevant, all individual status input, AC voltage input, and control output points shall be isolatable without the need to remove wiring by means of individual terminal blocks of the removable link type. In order to avoid open circuits on the secondary side of CTs, termination blocks with by-pass bridges shall be provided for all AC current inputs.

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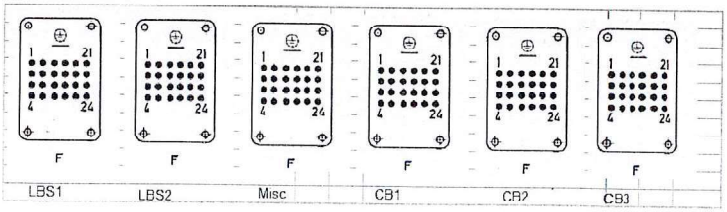
**Figure 2-1: RMU/RTU Connector Pin-Out Concept**

| Pin nrs | | LBS 1 | Pin nrs | | LBS 2 | Pin nrs | | Miscellaneous | Pin nrs | | CB1 | Pin nrs | | CB2 | Pin nrs | | CB3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | LBS 1: closed | 1 | 2 | LBS 2: closed | 1 | 2 | $SF_6$ Pressure: low (if applicable) | 1 | 2 | CB 1: closed | 1 | 2 | CB 2: closed | 1 | 2 | CB 3: closed |
| 3 | 4 | LBS 1: open | 3 | 4 | LBS 2: open | 3 | 4 | Charger AC: fail | 3 | 4 | CB 1: open | 3 | 4 | CB 2: open | 3 | 4 | CB 3: open |
| 5 | 6 | Spring 1: charged | 5 | 6 | Spring 2: charged | 5 | 6 | Voltage DC: low | 5 | 6 | Spring 1: charged | 5 | 6 | Spring 2: charged | 5 | 6 | Spring 3: charged |
| 7 | 8 | Earth switch 1: closed | 7 | 8 | Earth switch 2: closed | 7 | 8 | Battary alarms: Battary-failed, etc. | 7 | 8 | Earth switch 1: closed | 7 | 8 | Earth switch 2: closed | 7 | 8 | Earth switch 3: closed |
| 9 | 10 | Earth switch 1: open | 9 | 10 | Earth switch 2: open | 9 | 10 | Spare | 9 | 10 | Earth switch 1: open | 9 | 10 | Earth switch 2: open | 9 | 10 | Earth switch 3: open |
| 11 | 12 | Spare | 11 | 12 | FPI: overcurrent operated | 11 | 12 | Spare | 11 | 12 | Overcurrent relay 1: operated | 11 | 12 | Overcurrent relay 2: operated | 11 | 12 | Overcurrent relay 3: operated |
| 13 | 14 | Spare | 13 | 14 | FPI: earth fault operated | 13 | 14 | Spare | 13 | 14 | Earth fault relay 1: operated | 13 | 14 | Earth fault relay 2: operated | 13 | 14 | Earth fault relay 3: operated |
| 15 | 16 | LBS1: Local/Remote Status | 15 | 16 | LBS2: Local/Remote Status | 15 | 16 | Spare | 15 | 16 | CB1: Local/Remote Status | 15 | 16 | CB2: Local/Remote Status | 15 | 16 | CB3: Local/Remote Status |
| 17 | 18 | LBS 1 control: close | 17 | 18 | LBS 2 control: close | 17 | 18 | Spare | 17 | 18 | CB 1 control: close | 17 | 18 | CB 2 control: close | 17 | 18 | CB 3 control: close |
| 19 | 20 | LBS 1 control open | 19 | 20 | LBS 2 control open | 19 | 20 | Spare | 19 | 20 | CB 1 control: open | 19 | 20 | CB 2 control: open | 19 | 20 | CB 3 control: open |
| 21 | 22 | Door: open | 21 | 22 | Door: open | 21 | 22 | Spare | 21 | 22 | Door: open | 21 | 22 | Door: open | 21 | 22 | Door: open |
| 23 | 24 | Spare | 23 | 24 | FPI: reset | 23 | 24 | Spare | 23 | 24 | Spare | 23 | 24 | Spare | 23 | 24 | Spare |



Terminal blocks shall comply with IEC 60947-7-1: 2009 Low-voltage switchgear and control gear - Part 7-1: Ancillary equipment - Terminal Blocks for Copper Conductors. The LB may be read as OD and CB may be read as VL where necessary.

## 2.9 Support Facilities

The Employer intends to be self-reliant for both RTU hardware and firmware maintenance. To this end, the Contractor shall provide the support hardware, software, firmware, and documentation necessary to configure and repair the RTU. This shall include, but not be limited to, communication interfaces, printed-circuit card extenders, test cables, PROM programmer, maintenance manuals, RTU database compiler, firmware listings, RTU configuration listings, or other support facilities as applicable to the Contractor's RTU design.

# 3. RTU Characteristics

## 3.1 RTU Functions

The Contractor shall use as much standard hardware and firmware as possible; however, all of the functional requirements of this document must be satisfied.

### 3.1.1 Data Acquisition

The RTUs shall collect power system data including RMU data. In this respect, the RTU Contractor shall provide all necessary equipment for assigning data points to the RTU database. Further, using the 24 Vdc source from the RMU power supply unit, the Contractor shall provide the necessary wetting voltage, sensing voltage, current limiting, input isolation, and bounce filtering for all status (digital) inputs. The de-bounce time period for each status input shall be individually user configurable, and the input circuits of the status input modules shall be optically isolated from the external signal.

As a minimum, this data acquisition shall include:

**1- RMU Digital Input Points**

Load Break Switches:

- LBS status: closed/open
- Spring status: charged
- Earthing switch status: closed/open
- FPI status: operated (if FPI supported, one point for phase fault, one for earth fault)
- LBS: local/remote status
- Enclosure door status: open

Circuit Breakers :

- CB status: closed/open
- Spring status: charged
- Earthing switch status: closed/open
- Overcurrent relay: operated
- Earth fault relay: operated
- CB: local/remote status
- Enclosure door status: open

Miscellaneus:

- $SF_6$ Gas Pressure: low (if applicable to specific RMU)
- Charger AC: AC fail
- Voltage DC: low
- Battery alarms: Common indication corresponding to battery failed, etc.

Single as well as double status points shall be supported, where the latter relate to three-state switch positions reported in the form of two bits capable of representing one of four possible states, i.e., open, closed, in-transit, or indeterminate.

**2- IED Input Data**

**a) Meter Data**

The RTU shall be capable of reading data from the two (2) multifunction meters that will be provided with each RMU. These multifunction meters, one for each OD circuit, will measure electric power values such as voltage, current, active and reactive power, power factor, and active and reactive energy. They will be of 0.5 accuracy class and will provide data on a RS 485 communications port when polled by the RTU using the MODBUS protocol.

**b) Protection Relay Data**

The RTU shall be capable of reading all three (3) phase currents measured by each RMU protection relay corresponding to a VL's three-phase circuit breaker. The phase currents shall be read using MODBUS and the relay's RS 485 communications port. In addition, depending on the relay's specific features, the RTU shall be capable of interoperating with the relay using any other communicable I/O point as may be available. The RTU shall also monitor relay operations by having the relay's auxiliary contacts hardwired to the RTU.

### 3.1.2 Device Control

The RTU shall provide the DAS with the capability to select and control, i.e., open and close, the RMU circuit breakers and load break switches. It shall also allow the DAS to reset the FPI following a fault passage indication.

Each RTU shall be equipped with a manual switch that can be placed in one of two positions, i.e., "local" or "remote." The local position shall disable RMU device control from the DAS, whereas the remote position shall enable RMU device control from the DAS. Otherwise, in its local position, the switch shall not prevent:

(a) The RTU from monitoring and reporting RMU measurement and status data to the DAS

(b) The RTU panel from being used to control the RMU devices.

An auxiliary contact on the switch shall be wired to a contact input in the RTU to report the switch's local/remote status to the DAS.

The RMU Contractor will supply the interfaces to the RMU actuators and control devices. Signal interfaces to the RTU will be via signal quality potential-free contacts. The RMU Contractor will also provide any necessary interposing relays for any digital output to the control gear within the RMU enclosures. This includes the DC voltage to drive the interposing relays.

### 3.1.3 RTU Front Panel

Each RTU shall have a front panel showing a mimic diagram of the RMU's configuration. This shall include the presentation of RMU load break switch and circuit breaker status indications. In addition, with the RTU local/remote switch described in Clause above in its local position, the panel shall allow for manual (e.g., "push-button") control of each set of RMU load break switches and circuit breakers.

The RTU front panel shall be equipped with suitable connectors and ports including, for example, an RS 232 (sub-D 9) connector and one or more USB ports. These connectors and ports shall allow a laptop PC to be connected to the RTU for the purpose of performing local RTU configuration and diagnostic activities. These same ports shall also allow connection of the DAC simulator to be provided by BESCOM.

PLC Capability

The RTU shall have Programmable Logic Control (PLC) capability. In this respect, the PLC shall comply with the IEC 61131-3 programming standard.

### 3.1.4 Input /Output Point Counts

All RTUs shall be sized and equipped so that they can be used by the DAS to monitor and control 5-way RMUs even though in some cases they shall be installed in RMUs of different configuration. On this basis, the RTUs shall be wired to the RMU serial communication ports and to the RMU I/O points (including spares) using the connectors. For further I/O details refer to Table 3-1.

All points, including the spares as shown in Table 3-1, shall be fully configured and available for Employer use. The RTU shall also be delivered with an additional spare point capacity amounting to at least 10% for each of the digital input, control output, and IED data point totals in Table 3-1. These additional spares, however, need not be wired.

## 3.2 RTU Equipment Characteristics

### 3.2.1 Interface with RMU Multi-Function Meters and Numerical Relays

The RTU shall interface with the RMU multi-function meters and numerical relays using an RS 485 serial communications link and the MODBUS protocol. Wiring, cable, terminal, and data mapping details shall be finalized in conjunction with the RMU contractors and Employer. Communication cable lengths up to 6 m are anticipated.

**Table 3-1: RTU Data Point Count**

| DIGITAL INPUT | CONTROL OUTPUT | IED DATA |
|---|---|---|
| LBS 1<br>▪ LBS 1: closed<br>▪ LBS 1: open<br>▪ Spring 1: charged<br>▪ Earth switch 1: closed<br>▪ Earth switch 1: open<br>▪ LBS 1: local/remote status<br>▪ Door: open<br>LBS 2<br>▪ LBS 2: closed<br>▪ LBS 2: open<br>▪ Spring 2: charged<br>▪ Earth switch 2: closed<br>▪ Earth switch 2: open<br>▪ LBS 2: local/remote status<br>▪ Door: open<br>FPI<br>▪ overcurrent operated<br>▪ earth fault operated<br>CB1<br>▪ CB 1: closed<br>▪ CB 1: open<br>▪ Spring 1: charged<br>▪ Earth switch 1: closed<br>▪ Earth switch 1: open<br>▪ Overcurrent relay 1: operated<br>▪ Earth fault relay 1: operated<br>▪ CB 1: local/remote status<br>▪ Door: open<br>CB2<br>▪ CB 2: closed<br>▪ CB 2: open<br>▪ Spring 2: charged<br>▪ Earth switch 2: closed<br>▪ Earth switch 2: open<br>▪ Overcurrent relay 2: operated<br>▪ Earth fault relay 2: operated<br>▪ CB 2: local/remote status<br>▪ Door: open<br>CB3<br>▪ CB 3: closed<br>▪ CB 3: open<br>▪ Spring 3: charged<br>▪ Earth switch 3: closed<br>▪ Earth switch 3: open<br>▪ Overcurrent relay 3: operated<br>▪ Earth fault relay 3: operated<br>▪ CB 3: local/remote status<br>▪ Door: open<br>Miscellaneus<br>▪ $SF_6$ Pressure: Low (if applicable)<br>▪ Charger AC: Fail<br>▪ Voltage DC: Low<br>▪ Battery alarms: Battery-failed, etc.<br>**Total (with spares): 58** | LBS 1<br>▪ LBS 1: close<br>▪ LBS 1: open<br>LBS 2<br>▪ LBS 2: close<br>▪ LBS 2: open<br>CB 1<br>▪ CB 1: close<br>▪ CB 1: open<br>CB 2<br>▪ CB 2: close<br>▪ CB 2: open<br>CB 3<br>▪ CB 3: close<br>▪ CB 3: open<br>FPI<br>▪ Reset<br>**Total (with spares): 16** | Multifunction Meters<br>communications on MODBUS through RS485 ports (2 meters)<br>No. of Measurements:<br>▪ Voltage: 6<br>▪ Current: 6<br>▪ Active power: 6<br>▪ Reactive power: 6<br>▪ Power factor: 2<br>▪ Active Energy: 2<br>▪ Reactive Energy: 2<br>**Total Measurements: 30**<br><br>Feeder Protection Relays<br>communications on MODBUS through RS485 ports (up to 3 protection relays)<br>Minimum No. of Points:<br>▪ 7 points per relay<br>**Total Points: 9** |

### 3.2.2 External Communications Interface

The RTUs shall have two ports available for the primary means of communicating with the DAS via the Employer's communications system. One shall be an Ethernet TCP/IP (RJ45) port, and one shall be a Serial (RS-232C) port. Both ports shall be capable of operating at 9.6 kbps (or higher) in conjunction with the MARS remote radio and communications system provided by others. Only one of these ports, however, shall be used for DAS communications at any given time.

The port that is not used for primary communications may be used for other purposes such as:

1) Local testing using the DAC simulator

2) Future dial-up connections via suitable telephone services

3) Backup communications or future collection of non-operations data using, for example, leased-line or GPRS services.

In this respect, all external services and devices (such as modems) will be provided by the Employer.

### 3.2.3 Communication Protocols

With reference to Clause above, the RTU Ethernet and Serial ports shall be configured with the DNP/IP and DNP 3 communications protocols, respectively.

In addition to these protocols, the RTU port for communications with the RMU's multifunction meters and protection relays shall use MODBUS.

All protocols shall be implemented by modifiable firmware in the RTU. No external gateways for protocol conversions shall be necessary.

The Employer shall be authorized to disclose the RTU protocol implementation profiles to third-party contractors of Employer equipment. In the case of DNP, relevant profile and data mapping details shall be coordinated. Similarly, in the case of MODBUS, these details shall be coordinated in cooperation with the RMU contractor and, if necessary, the respective manufacturers of the RMU's multifunction meters and protection relays.

### 3.2.4 Status/Analog Reporting Modes

Power system input data collected by the RTU shall be able to be reported to the DAS Master Station using the following possible modes of operation:

1) Report by Exception: The RTU shall report status/analog changes by exception. That is, the RTU replies to a DAS Master Station scan command by sending only the status/analog changes that have occurred during the scan time interval.

2) Unsolicited: The RTU shall report status/analog changes in an unsolicited spontaneous manner. That is, the RTU itself reports to the DAS any change to the status/analog points collected without the need of a scan command from the DAS.

3) General Interrogation: The RTU shall report all status/analog values in response to a cyclic DAS general scan command.

4) Demand Interrogation: The RTU shall report selected status/analog points in response to a DAS demand scan request.

Scan rates and deadbands (used to detect significant analog changes) shall be programmable. In addition, deadbands shall be programmable on an individual point basis.

### 3.2.5 Select-Check-Before-Execute Control Security

Control output implementations shall apply a select-check-before-execute command sequence. The control sequence shall include, as a minimum, the following capabilities:

1) The DAS shall transmit a command message addressing the proper RTU and control point within the RTU as well as indicating the control action desired.

2) The RTU shall initialize its control logic, reassemble the command message, and transmit the reassembled message to the DAS. The message sent to the DAS shall be generated by the RTU's point selection logic; it shall not be a simple repeat of the DAS transmission.

4) The DAS shall check the returned message for validity and, if valid, shall issue an execute command to the RTU.

5) The RTU shall only operate the control point selected, and only after the execute command has been received.

The control action shall be executed only if the select-check-before-execute sequence is performed without error or interruption by other messages. The RTU shall reset its control logic upon any error in the sequence or if the execute command is not received within a software engineer-definable time, typically 30 seconds, after the command message is received by the RTU.

### 3.2.6 Message Security

Each message transmitted shall include an error detection code to exclude erroneous messages being accepted as valid.

### 3.2.7 Control Simulation Test Facilities

Each RTU shall be equipped with an internal mechanism for simulating the response to a control output message. This control simulation facility shall be capable of being linked to any control point in the RTU. This facility shall simulate the change of state and the state indication of the linked point upon receipt of a valid control output message from the DAS or from locally applied test equipment.

### 3.2.8 RTU Time Synchronization

The RTUs shall have an internal clock for data collection coordination and time tagging with a drift of no more than 1 second per day, which corresponds to a clock accuracy of 10 ppm. To meet this requirement, the RTU may apply a time correction algorithm.

The RTU time source shall support the capability of the RTU to time tag operations data (i.e., real-time data) and, for possible future application, non-operations data used for post-mortem analysis. The non-operations data could include power quality data such as disturbance and waveform records.

Each RTU shall synchronize its internal clock from the DAS through the DNP communications protocol. Alternatively, should it be necessary, the RTU shall support time synchronization via the Network Time Protocol (NTP).

### 3.2.9 Power Supply

The RTUs shall make use of the 24 Vdc source of power furnished by the RMU supplier and, on this basis, the RTU input and output circuits shall be capable of operating reliably for any voltage between 16 and 32 Vdc. The RTUs shall be capable of operating with ungrounded or grounded (i.e., either polarity) input power. The RTUs, however, shall not place a ground on the input power.

### 3.2.10 Enclosures and Space Requirements

The RTUs shall be supplied in galvanised or stainless steel enclosures having a protection index of at least IP54. The Contractor shall specify the unit dimensions as well as the installation requirements.

Within this context, the RTU enclosures shall meet the following specific requirements:

1) They shall be capable of being accommodated within the DAS RMU enclosures provided by the RMU Contractors. The RMU space currently allocated for the RTU is 600 mm (W) x 500 mm (D) x 600 mm (H).

2) They shall have lockable doors allowing maintenance access to the hardware and wiring. Swing racks supported by heavy gauge hinges shall be provided so that only front access to components and wiring is required for routine maintenance and troubleshooting.

3) They shall have provisions for top and bottom cable entry. Cable entries shall be provided with protection against insect and animal entry, and shall be sealed to prevent dust and sand contamination.

4) There shall be suitable signal and safety ground networks within the enclosure. The safety ground shall be isolated from the signal ground and shall connect to the ground wire of the power input. The signal ground shall terminate at a separate stud connection sized for a lugged 2/0 ground wire. Each ground network shall be a copper bus bar, braid, or cable. Use of the enclosure frame, skins, or chassis mounting hardware for the ground network is not acceptable.

## 3.3 RTU Software/Firmware

The RTUs shall meet the following software/firmware requirements to support the functions of the RTUs. The term firmware, as used herein shall mean PROM-based and user friendly software which may be provided to satisfy the Employer's requirements. The Contractor shall use standard firmware as much as possible.

### 3.3.1 Design Characteristics

All firmware shall be completely and consistently documented. It shall not be necessary to perform modification to firmware, logic, or data for expansion within the sizing parameters defined for the RTU.

At the time the RTU is accepted, all firmware delivered must be up to date and in final form, including all standard firmware changes and field changes initiated by the Contractor or any associated sub-contractor prior to acceptance. The firmware documentation must reflect these changes.

### 3.3.2 Initialization/Restart Program

Firmware shall be provided to enable the RTU to safely restart itself upon manual request and automatically under the conditions of power restoration, memory parity errors, and hardware failures. The firmware shall initialize the RTU and begin execution of the RTU functions without intervention by the DAS. All RTU restarts shall be reported to the DAS.

### 3.3.3 RTU Operations Monitoring Firmware

Firmware shall be provided to continuously monitor operation of the RTU and report its hardware errors to the DAS. The firmware shall check for memory, CPU, communication faults, and input/output errors and failures. All detected errors shall be reported to the DAS.

### 3.3.4 Fail Safe Processing

In the case of irrecoverable faults such as power supply failures, firmware malfunctions, or any other detected condition that may affect the security of indications and controls, the RTU shall place itself in a secure state that prohibits the transmission of false indications or the execution of erroneous control outputs. The detection of these error conditions shall be the responsibility of the RTU's self-test and operations monitoring firmware.

### 3.3.5 Database Maintenance

The Contractor shall supply software to configure each RTU's database where this information is located in software and/or firmware at the RTU. The software shall completely generate or modify the database of the RTUs. The database software shall have error detection services and shall produce a printed listing of the input data and the resulting RTU database configuration.

The RTU shall support changes made to the RTU's configuration and processing parameters (such as measurement deadbands) by downloading relevant data from the DAS. The contractor shall provide a single file for download.

### 3.3.6 Diagnostic Firmware

The Contractor shall supply diagnostic firmware for both off-line local tests and on-line self-diagnostic capability built into the RTU. The RTU shall enter an off-line state during the execution of off-line diagnostics, and this off-line state shall be reported to the DAS.

### 3.3.7 Diagnostic Ports

The RTU Ethernet and Serial communication ports shall be capable of being used for remote diagnostics from the DAS and from any external computer terminal with a suitable communications connection. This shall include the capability to support auto-answer dial-in operations.

## 3.4 RTU Test Sets

The Contractor shall supply RTU test sets for performing the functions listed below. Laptop PCs shall be used for this purpose. The RTU test system shall comply with the following requirements:

1) Each test system shall support all maintenance aspects such as verifying proper operation, troubleshooting, reconfiguring, and setting operational parameters for the RTUs.

2) The test systems shall support all functional capabilities of the RTUs, including functions that are not explicitly required in these Technical Specifications and functions that may not be included in the delivered RTUs.

3) It shall be possible to use a test system locally at the site of the RTU under test, and also remotely wherever access can be obtained to the communication channel of the RTU.

4) All the required data rates shall be easily selectable.

5) It shall be possible to use the test systems to monitor communications between the DAS and the RTUs by selecting specific data streams, or portions of such data streams, both to and from an RTU. The data shall be displayed in a form that is easy for the user to interpret.

6) It shall be possible to connect the test system directly to the RTU and to use the test system to perform all necessary RTU management and expansion functions, monitor all stored data, monitor RTU inputs, exercise RTU outputs, and diagnose and troubleshoot the RTU. It shall also be possible to use the test system as a local user interface at the RTU location.

7) No programming skills shall be required to use the field test system. Interactive procedures relying mostly on pull down menus shall be used. The user shall not be required to type in commands, and shall be prompted when data entry is needed.

8) The test systems shall be ruggedly constructed and suitable for field work and transportation in trucks. All cables, connectors, equipment, and documentation associated with their operation shall be included and stored either within the test system package or in suitable separate containers.

9) The test systems shall operate on internal battery and 230 Vac, 50 Hz.

# 4. RTU Inspection and Test

All RTU materials including hardware, firmware, and associated equipment and devices to be furnished and all work to be performed under this Specification shall be subject to inspections and tests. No RTUs materials shall be shipped until all required inspections and tests have been made, demonstrating that they conform to the Specification and have been approved for shipment by the Employer.

Approval of inspection and test results, acceptance of RTU materials or the waiving of inspection and tests thereof, shall in no way relieve the Contractor of the responsibility for furnishing materials that meet the requirements of this Specification, nor shall such actions invalidate any claim that the Employer may make because of defective or unsatisfactory RTU materials. The Employer reserves the right to request additional tests on the RTUs at no extra charge in connection with any work the Employer determines not to be in accordance with these Technical Specifications.

Whenever the results of any inspections or tests performed or requested by the Employer in accordance with the requirements of this Clause indicate that specific hardware, firmware, electrical equipment, devices or documentation does not meet the specified requirements, the Contractor shall replace, modify, or add, at no cost to the Employer, RTU hardware, firmware, electrical equipment, devices, or documentation as necessary to correct the noted deficiencies.

One sample RTU shall be provided to the DAS contractor for testing purposes.

## 4.1 Inspection

Representatives of the Employer shall have free entry into the facilities of the RTU and electrical equipment manufacturers at any time while design, fabrication, or testing of the equipment is taking place and into any mill, shop, or factory where the hardware or firmware described in these Technical Specifications is being produced.

The Contractor shall provide to the Employer's representatives, free of cost, all reasonable facilities, equipment, and documentation necessary to satisfy the representatives that the RTUs and electrical equipment are being fabricated in accordance with the Specifications. The inspection rights described above shall apply to the facilities of the Contractor or the Contractor's subcontractor where the RTUs and electrical equipment are being manufactured. The inspection rights shall not apply to the facilities of subcontractors supplying unit components to the RTU manufacturer. Such items will be inspected and tested by the Employer's representatives at the main manufacturing site.

Inspections by the Employer's representatives will include visual examination of the physical appearance of the RTU hardware and associated equipment along with all cable dressings, and labeling details. Contractor documentation will also be examined to verify that it adequately identifies and describes all RTU hardware, firmware, devices, and spare parts. The Employer shall have access to inspect the Contractor's and manufacturer's quality assurance standards, procedures, and records that are applicable to this RTU Construction Package. Inspection shall not relieve the Contractor of the responsibility for furnishing material and equipment conforming to the requirements of the

Technical Specifications, nor shall such inspection invalidate any claim that the Employer may make because of defective or unsatisfactory RTU hardware or firmware, electrical equipment or design.

## 4.2 Test Procedures

All equipment shall be tested in accordance with the Contractor's standard procedures. The Contractor shall submit a detailed description of these test procedures. This shall be preceded by the submission of an RTU test plan.

The RTU test plan shall be submitted for Employer's approval prior to the start of factory tests. The corresponding test procedures shall be submitted for approval prior to the tests. The Employer will only approve test procedures if they are inclusive, thoroughly testing each section of the equipment. The Contractor shall use ANSI MC8.1, "Recommended Practice, Hardware Testing of Digital Process Computers," as a guide in preparing the RTU test procedures. The test procedures shall include the following:

1) The test schedule including provision for eight hours of unstructured tests to be performed by the Employer
2) The purpose of each test
3) The function to be tested
4) The plans/procedures to be followed
5) Specific references to project documentation for correlation with the procedures and for verification of the documentation
6) The test setup, equipment, and conditions for each part of the test
7) All test inputs and outputs
8) Test firmware descriptions and listings
9) A copy of any certified test data to be used in lieu of testing
10) Expected results
11) The acceptance criteria
12) A procedure for handling the variances that are identified during testing.

All RTU factory and field performance testing shall include use of the Data Acquisition and Control (DAC) Simulator to be provided by the BESCOM. In this respect, the DAC Simulator shall be used to verify the capability of each RTU to interoperate with the DAS prior to actual integration of the RTU with the DAS via the Employer's communications system.

## 4.3 Test Records

The Contractor shall maintain a complete record of the results of all tests. This record shall be keyed to the steps enumerated in the previously approved test plan. The record shall include the following items:

1) Reference to the appropriate section of the test plan
2) Description of any special test conditions or special action taken
3) Test results, passed/failed.

A copy of the test records shall be delivered to the Employer at the conclusion of the tests.

## 4.4 Type Tests

The RTUs shall have passed type tests in accordance with IEC 60255-3, IEC 60255-5, IEC 60255-6, IEC 61000-4-2, and IEC 61000-4-3 to demonstrate that the RTUs comply with these standards. As a minimum, the following type tests shall be included:

1) Dielectric tests
2) Impulse voltage withstand tests
3) High frequency disturbance tests
4) Thermal requirement tests
5) Mechanical requirement tests
6) Limiting dynamic value tests
7) Contact performance tests
8) Electromagnetic radiation susceptibility tests
9) Electrostatic discharge susceptibility tests

## 4.5 Factory Tests

All RTUs shall successfully pass a set of routine tests before being accepted for delivery. These tests shall be performed by the Contractor and, at the option of the Employer, in the presence of one or more Employer's representatives. The routine tests shall be based on an approved subset of the test procedures. Otherwise, given that the RTUs will be delivered in batches on different delivery dates, at least one RTU from each batch shall be subject to the complete set of approved test procedures. This

complete testing shall be witnessed by the Employer's representatives and shall include, but not be limited to, all of the following functional and performance tests:

1) Inventory check and inspection for general appearance, cabling, drawing conformance, and labeling

2) Checks of proper functioning of all hardware and firmware by a thorough exercising of all RTU functions, both individually and collectively

3) Simulation of inputs, including noise and transient conditions, using convenient test panels which allow each input to be varied over its entire range via individual setters

4) Checks of power supply voltage margins, ripple levels, and short-circuit protection

5) Test of all digital input points

6) Test of all control outputs

7) Test of power failure and recovery

8) Tests of communications and down-line loading of configuration changes

9) Test of equipment spares through substitution

10) Checks to verify the accuracy of hardware and firmware documentation

11) Demonstration of techniques and methods for modifying the database, including point additions and deletions

12) Tests conducted to verify the test set capabilities and operations. All on-line, offline, and remote diagnostic features and equipment shall be tested

13) Test under full-power and simulated operation for a minimum of 48 hours. Twelve hours of this test shall be at the specified high temperature limit. The RTU shall demonstrate continuous operation without any failures. This operation shall include periodic scanning of all points and demonstration that all RTU functions operate properly.

Test procedure annexed as annexure A.

## 4.6 Field Performance Tests

The field performance test shall be conducted by the Contractor's personnel after installing, starting, and checking the equipment at the field location. All hardware shall be aligned and adjusted, interfaces to all inputs and outputs established, operation verified, and all test readings recorded in accordance with the Contractor's recommended procedures. The field performance test shall exercise all RTU functions with respect to monitoring and controlling the RMUs in which the RTUs are

actually installed. To the extent possible, this shall include duplication of selected factory acceptance tests. Otherwise, testing shall include, but not be limited to, the following conditions:

1) RTU initialization

2) Diagnostics

3) Checks of proper functioning of hardware and firmware by exercising of selected RTU functions

4) RTU communication interfaces including failure modes

5) Database modifications, including point changes and RTU download capability.

Test procedure annexed as annexure B

# 5. RTU Training and Support Services

The Contractor shall provide the training and support services that will be used to develop the Employer's in-house maintenance and support capabilities for the RTU hardware, software, and firmware. The training program shall be comprehensive and include interdisciplinary training of hardware and firmware. Required training of the Employer's personnel shall be conducted in English languages by the Contractor. All training material shall be also provided in English.

## 5.1 RTU Maintenance Training

The Contractor shall provide RTU maintenance training. The course shall familiarize the course participants with RTU installation, module level troubleshooting and repair procedures, and the recommended preventive maintenance procedures for the RTU equipment. Course coverage shall include the use of the RTU test set and DAC Simulator and shall demonstrate all facets of RTU operation. The course shall include hands-on experience with the RTUs supplied by the Contractor and shall cover any special equipment required for maintenance. The Contractor shall utilize the actual RTUs to be supplied to the Employer during this training.

# 6. RTU Documentation

## 6.1 Documentation

### 6.1.1 Test Documentation

The Contractor shall provide documentation for all factory and field tests as per Clause 4, RTU Inspection and Test.

| | RTU MODBUS communication details with IED's | | | | |
|---|---|---|---|---|---|
| | **METER:**<br>**Protocol: Modbus communication ( RS 485)**<br>**Baud Rate: 9600**<br>**Parity : None**<br>**Stop Bit: 01**<br>**RELAY :**<br>**Protocol: Modbus communication ( RS 485)**<br>**Baud Rate: 9600**<br>**Parity : None**<br>**Stop Bit: 01** | | | | |
| **Modbus address** | **Modbus - Bit Index** | **Modbus - Subtype** | **Scaling**<br>**RTU side** | **Description** | **DNP Address** |
| 3925 | 3 | 32 bit float | *100 | Meter 1 R Y Voltage | 0 |
| 3939 | 3 | 32 bit float | *100 | Meter 1 Y B Voltage | 1 |
| 3953 | 3 | 32 bit float | *100 | Meter 1 B R Voltage | 2 |
| 3929 | 3 | 32 bit float | *10 | Meter 1 R Phase Current | 3 |
| 3943 | 3 | 32 bit float | *10 | Meter 1 Y Phase Current | 4 |
| 3957 | 3 | 32 bit float | *10 | Meter 1 B Phase Current | 5 |
| 3903 | 3 | 32 bit float | /1000 | Meter 1 Total Active Power (kW) | 6 |
| 3905 | 3 | 32 bit float | /1000 | Meter 1 Total Reactive Power (kVAr) | 7 |
| 3925 | 3 | 32 bit float | *100 | Meter 2 R Y Voltage | 8 |
| 3939 | 3 | 32 bit float | *100 | Meter 2 Y B Voltage | 9 |
| 3953 | 3 | 32 bit float | *100 | Meter 2 B R Voltage | 10 |
| 3929 | 3 | 32 bit float | *10 | Meter 2 R Phase Current | 11 |
| 3943 | 3 | 32 bit float | *10 | Meter 2 Y Phase Current | 12 |
| 3957 | 3 | 32 bit float | *10 | Meter 2 B Phase Current | 13 |
| 3903 | 3 | 32 bit float | /1000 | Meter 2 Total Active Power (kW) | 14 |
| 3905 | 3 | 32 bit float | /1000 | Meter 2 Total Reactive Power (kVAr) | 15 |
| 40 | 4 | UNIT32(big Endian) | /10 | Protection Relay 1 R Phase Current | 16 |
| 42 | 4 | UNIT32(big Endian) | /10 | Protection Relay 1 Y Phase Current | 17 |
| 44 | 4 | UNIT32(big Endian) | /10 | Protection Relay 1 B Phase Current | 18 |
| 40 | 4 | UNIT32(big Endian) | /10 | Protection Relay 2 R Phase Current | 19 |
| 42 | 4 | UNIT32(big Endian) | /10 | Protection Relay 2 Y Phase Current | 20 |
| 44 | 4 | UNIT32(big Endian) | /10 | Protection Relay 2 B Phase Current | 21 |
| 40 | 4 | UNIT32(big Endian) | /10 | Protection Relay 3 R Phase Current | 22 |
| 42 | 4 | UNIT32(big Endian) | /10 | Protection Relay 3 Y Phase Current | 23 |
| 44 | 4 | UNIT32(big Endian) | /10 | Protection Relay 3 B Phase Current | 24 |

| | | | | | |
|---|---|---|---|---|---|
| 49 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 1 R Phase Fault Current | 25 |
| 51 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 1 Y Phase Fault Current | 26 |
| 53 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 1 B Phase Fault Current | 27 |
| 49 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 2 R Phase Fault Current | 28 |
| 51 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 2 Y Phase Fault Current | 29 |
| 53 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 2 B Phase Fault Current | 30 |
| 49 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 3 R Phase Fault Current | 31 |
| 51 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 3 Y Phase Fault Current | 32 |
| 53 | 4 | UNIT32(big Endian) | *0.002 | Protection Relay 3 B Phase Fault Current | 33 |
| 55 | 4 | UNIT32(big Endian) | *0.002 | EFR Relay 1 Fault Current | 34 |
| 55 | 4 | UNIT32(big Endian) | *0.002 | EFR Relay 2 Fault Current | 35 |
| 55 | 4 | UNIT32(big Endian) | *0.002 | EFR Relay 3 Fault Current | 36 |
| 3867 | 3 | 32 bit float | *100 | Meter 1 % THD I (Current) | 37 |
| 3867 | 3 | 32 bit float | *100 | Meter 2 % THD I (Current) | 38 |

| Modbus address | Modbus - Bit Index | Modbus - Subtype | Scaling | Description | DNP Address |
|---|---|---|---|---|---|
| | | | RTU side | | |
| **RTU Point List (Calculated)COUNTERS** | | | | | |
| 3961 | 3 | 32 bit float | /1000 | Meter 1 Total Active Energy (24 hours) | 39 |
| 3963 | 3 | 32 bit float | /1000 | Meter 1 Total Reactive Energy (24 hours) | 40 |
| 3961 | 3 | 32 bit float | /1000 | Meter 2 Total Active Energy (24 hours) | 41 |
| 3963 | 3 | 32 bit float | /1000 | Meter 2 Total Reactive Energy (24 hours) | 42 |
| **RTU Point List (IED) DI** | | | | | |
| 30 | 3 | UNIT16(big Endian) | | Relay 1 Group A/B Active | 59 |
| 30 | 3 | UNIT16(big Endian) | | Relay 2 Group A/B Active | 60 |
| 30 | 3 | UNIT16(big Endian) | | Relay 3 Group A/B Active | 61 |
| **Pkg II Point List (IED) AO** | | | | | |
| 64 | 6 | UNIT16(big Endian) | | Relay 1 Group A/B Active | 0 |
| 64 | 6 | UNIT16(big Endian) | | Relay 2 Group A/B Active | 1 |
| 64 | 6 | UNIT16(big Endian) | | Relay 3 Group A/B Active | 2 |

| RTU Point List (Digital Input) | | | | |
|---|---|---|---|---|
| Interface with RMU | | RTU | | |
| Interface Connector Designation | Interface Connector Pin-out | RTU Terminal Block Number (particular per RTU manufacturer) | Description | DNP Address |
| OD 1 | 1-2 | OD1.2 | OD 1 Closed | 0 |
| OD 1 | 3-4 | OD1.3 | OD 1 Open | 1 |
| OD 1 | 7-8 | OD1.5 | OD 1 Earth Switch 1 Closed | 2 |
| OD 1 | 9-10 | OD1.6 | OD 1 Earth Switch 1 Open | 3 |
| OD 1 | 15-16 | OD1.9 | OD 1 Local/Remote Status | 4 |
| OD 1 | 21-22 | OD1.10 | OD 1 Door Open | 5 |
| OD 2 | 1-2 | OD2.3 | OD 2 Closed | 6 |
| OD 2 | 3-4 | OD2.2 | OD 2 Open | 7 |
| OD 2 | 7-8 | OD2.5 | OD 2 Earth Switch 2 Closed | 8 |
| OD 2 | 9-10 | OD2.6 | OD 2 Earth Switch 2 Open | 9 |
| OD 2 | 15-16 | OD2.9 | OD 2 Local/Remote Status | 10 |
| OD 2 | 21-22 | OD2.10 | OD 2 Door Open | 11 |
| OD 2 | 11-12 | OD2.7 | FPI Overcurrent Operated | 12 |
| OD 2 | 13-14 | OD2.8 | FPI Earth Fault Operated | 13 |
| VL 1 | 1-2 | VL1.3 | VL 1 Closed | 14 |
| VL 1 | 3-4 | VL1.2 | VL 1 Open | 15 |
| VL 1 | 5-6 | VL1.4 | VL 1 Spring 1 Charged | 16 |
| VL 1 | 7-8 | VL1.5 | VL 1 Earth Switch 1 Closed | 17 |
| VL 1 | 9-10 | VL1.6 | VL 1 Earth Switch 1 Open | 18 |
| VL 1 | 11-12 | VL1.7 | VL 1 Overcurrent Relay 1 Operated | 19 |
| VL 1 | 13-14 | VL1.8 | VL 1 Earth Fault Relay 1 Operated | 20 |
| VL 1 | 15-16 | VL1.9 | VL 1 Local/Remote Status | 21 |
| VL 1 | 21-22 | VL1.10 | VL 1 Door Open | 22 |
| VL 2 | 1-2 | VL2.3 | VL 2 Closed | 23 |
| VL 2 | 3-4 | VL2.2 | VL 2 Open | 24 |
| VL 2 | 5-6 | VL2.4 | VL 2 Spring 2 Charged | 25 |
| VL 2 | 7-8 | VL2.5 | VL 2 Earth Switch 2 Closed | 26 |
| VL 2 | 9-10 | VL2.6 | VL 2 Earth Switch 2 Open | 27 |
| VL 2 | 11-12 | VL2.7 | VL 2 Overcurrent Relay 2 Operated | 28 |
| VL 2 | 13-14 | VL2.8 | VL 2 Earth Fault Relay 2 Operated | 29 |
| VL 2 | 15-16 | VL2.9 | VL 2 Local/Remote Status | 30 |

| | | | | |
|---|---|---|---|---|
| VL 2 | 21-22 | VL2.10 | VL 2 Door Open | 31 |
| VL 3 | 1-2 | VL3.3 | VL 3 Closed | 32 |
| VL 3 | 3-4 | VL3.2 | VL 3 Open | 33 |
| VL 3 | 5-6 | VL3.4 | VL 3 Spring 3 Charged | 34 |
| VL 3 | 7-8 | VL3.5 | VL 3 Earth Switch 3 Closed | 35 |
| VL 3 | 9-10 | VL3.6 | VL 3 Earth Switch 3 Open | 36 |
| VL 3 | 11-12 | VL3.7 | VL 3 Overcurrent Relay 3 Operated | 37 |
| VL 3 | 13-14 | VL3.8 | VL 3 Earth Fault Relay 3 Operated | 38 |
| VL 3 | 15-16 | VL3.9 | VL 3 Local/Remote Status | 39 |
| VL 3 | 21-22 | VL3.10 | VL 3 Door Open | 40 |
| MISC | 1-2 | MISC.2 | SF6 Pressure Low | 41 |
| MISC | 3-4 | MISC.3 | Charger AC Fail | 42 |
| MISC | 5-6 | MISC.4 | Voltage DC Low | 43 |
| MISC | 7-8 | MISC.5 | Battery Alarm Battery Failed | 44 |
| MISC | 11-12 | XSP1.3 | Control Cabinet Door Open | 45 |
| - | - | - | Dummy Latching Relay Open / Close | 46 |
| | | | RTU Local/Remote Status | 47 |
| - | - | - | RTU Door Open | 48 |
| - | - | - | Meter 1 Offline | 49 |
| - | - | - | Meter 2 Offline | 50 |
| - | - | - | Relay 1 Offline | 51 |
| - | - | - | Relay 2 Offline | 52 |
| - | - | - | Relay 3 Offline | 53 |
| MISC | 13-14 | XSP1.4 | Spare 6 | 54 |
| MISC | 15-16 | XSP1.5 | Spare 7 | 55 |
| MISC | 17-18 | XSP1.6 | Spare 8 | 56 |
| MISC | 19-20 | XSP1.7 | Spare 9 | 57 |
| MISC | 21-22 | XSP1.8 | Spare 10 | 58 |

| RTU Point List (Digital Output) | | | | |
|---|---|---|---|---|
| Interface Connector Designation | Interface Connector Pin-out | RTU Terminal Block Number (particular per RTU manufacturer) | Description | DNP Address |
| OD 1 | 17-18 | OD1.13/14 | OD 1 Close | 0 |
| OD 1 | 19-20 | OD1.11/12 | OD 1 Open | 1 |
| OD 2 | 17-18 | OD2.13/14 | OD 2 Close | 2 |
| OD 2 | 19-20 | OD2.11/12 | OD 2 Open | 3 |
| VL 1 | 17-18 | VL1.13/14 | VL 1 Close | 4 |
| VL 1 | 19-20 | VL1.12/12 | VL 1 Open | 5 |
| VL 2 | 17-18 | VL2.13/14 | VL 2 Close | 6 |
| VL 2 | 19-20 | VL2.12/12 | VL 2 Open | 7 |
| VL 3 | 17-18 | VL3.13/14 | VL 3 Close | 8 |
| VL 3 | 19-20 | VL3.12/12 | VL 3 Open | 9 |
| OD 2 | 23-24 | OD2.15/16 | FPI Reset | 10 |
| | - | - | Dummy Latching Relay Open/Close | 11 |
| OD 2 | 23-24 | XSP2.1/2 | Spare 1 | 12 |
| VL1 | 23-24 | XSP2.3/4 | Spare 2 | 13 |
| VL2 | 23-24 | XSP2.5/6 | Spare 3 | 14 |
| VL3 | 23-24 | XSP2.7/8 | Spare 4 | 15 |
| MISC | 23-24 | XSP2.9/10 | Spare 5 | 16 |

# Outstation Device Profile Recommendations

## 1. Purpose and scope

The recommendations to ensure configuration standardization between all contract providers of RTU, contributing in that way to a better performance of the overall system.

## 2. Acronyms

**DAFE**: Data Acquisition Front End

**DAS**: Data Acquisition System (Master Station)

**RTU**: Remote Terminal Unit

**Deadband**: A value, normally a delta or percent, by which a point must change since it was last reported before it can be reported again.

**RTS**: RS-232 signal. Request To Send

**CTS**: RS-232 signal. Clear To Send

**CD, DCD**: RS-232 signal. Carrier Detect, Data Carrier Detect

## 3. Description

The following requirements and suggestions help to reduce communication congestion over the radio infrastructure. This document has been updated to clarify and explain in more detail, the requirements and defaults necessary for the BESCOM system.

1. **Serial Connections**
   a. RTU Receiver Inter-character timeout: set to "no gap permitted";
   b. Inter-character gap in transmission: set to "none" (always transmits with no inter-character gap).
   c. Time synchronization support: Set to "DNP3 Delay Measurement", followed by "DNP3 Write Time".
   d. 8 databits, No parity, One stop bit, 19.2 kbps datarate

2. **IP Networking**
   a. Type of endpoint: set to "TCP listening";
   b. Accepts TCP Connections or UDP Datagrams from: set to "allows all" (show as *.*.*.*);
   c. TCP Listen Port Number of remote device: set to 20,000;
   d. Time synchronization support:
      i. "DNP3 Record Current Time", followed by "DNP3 Write Time", and
      ii. "DNP3 Delay Measurement", followed by "DNP3 Write Time".
      By default "DNP3 Delay Measurement" shall be set.

3. **Link Layer**
   a. Sends Confirmed User Data Frames: set to "Never"
   b. Data Link Layer Confirmation Timeout: set to "None";

c. Maximum Data Link Retries: set to "Never retries";
d. Receive frame timeout set to: 5 s
e. Maximum number of octets Transmitted in a Data Link Frame: set 292;
f. Maximum number of octets that can be Received in a Data Link Frame: set to 292;
g. Sends Multi-Fragment Responses: set to "No";

**4. Application Layer**

a. Maximum number of octets Transmitted in an Application Layer Fragment other than File Transfer: set to 249;
b. Maximum number of octets Transmitted in an Application Layer Fragment containing File Transfer: shall be set to 249;
c. Maximum number of octets that can be Received in an Application Layer Fragment: shall be set to 249;
d. Timeout waiting for Complete Application Layer Fragment: Configurable between 0 and 120,000ms. By default shall be set to 60,000ms.
e. Unsolicited Response Confirmation Timeout: Configurable between 0 and 120,000ms. By default shall be set to 60,000ms.
f. Event Buffer Overflow behavior: set to "Discard the newest event";
g. Requests Application Confirmation: for event responses and to non-final fragments set to "Yes";
h. Number of unsolicited retries: set to "Configurable, range 0 to 10". By default shall be set to 3.

**5. Time**

a. Each outstation shall request time on power up or reset if it requires time;
b. An outstation may not request time under other circumstances;
c. The DAS master will send time at a defined interval, currently 24 hours;
d. The outstation shall synchronize using object=50, variation=1.

**6. Digitals/Status**

a. Status values shall be binary with time
    i. Preferred object=2, variation=2. Supported Function Codes=129, 130. Supported Qual Codes (hex)=17, 28.
b. Status change values shall be reported in a class 1 poll.
c. Number of class 1 events that trigger Class 1 unsolicited response: set to "Configurable, range 1 to 255"; *Default set to 5.
d. Hold time after class 1 event: set to "Configurable, range 1 to 60,000ms" *Default set to 5,000ms.

**7. Analogs**

a. Analog values shall be 16 bits
    i. Preferred object=30, variation=2. Supported Function Code=129. Supported Qual Codes (hex)=00, 01; *object=32, variation=2 is also supported and expected for unsolicited changes.
b. *Pertains to both hardwired discrete points and metered data from other downstream sources.
c. Analog values will be scaled at the DAS master to engineering values;
d. The default deadband on analog values shall default to 10% of a signed 16 bit value (10% of 32767 is 3277); *Voltage measurements can be set with a tighter deadband tolerance of 5% of the signed 16 bit value.
e. Deadbands shall be configurable via the deadband object from the DAS master. Deadband values will be adjusted using object=34;
f. Analog change values shall be reported in a class 2 poll.

g. Number of class 2 events that trigger Class 2 unsolicited response: set to "Configurable, range 1 to 255"; *Default set to 10.
h. Hold time after class 2 event: set to "Configurable, range 1 to 60,000ms" *Default set to 30,000ms.

**8. Analog Outputs (from the DAS)**

**a.** Analog outputs shall be 16-bit signed integers.
  **i.** Object=41 variation=1 and variation =2 are both supported
**b.** Analog Outputs sent from the DAFF will appear to be control commands and issued in the same manner as controls.

**9. Counters**

a. Counter values shall be 32 bits
b. Preferred object=21, variation=1. Supported Function Code=129. Supported Qual Codes (hex)=00, 01. All counters in each RTU are to be reported once per day to the DAS, with the value held locally (RTU) at midnight (00h00). No broadcast or individual freeze will be provided by the DAS.
c. The counters shall be retrieved only by DAS request. This avoids the communications conflicts that would be generated if every RTU tried to send its counters at the same time (00h00).
d. Counter values will be scaled at the DAS master to engineering values.
e. Counter MIN and MAX values are needed to properly handle rollover. These values are not reported by the RTU.
f. There will be no counter dead bands.
g. Counter frozen values shall be reported in a class 3 poll.
h. Class 3 will only contain counters data. The RTU will not generate class 3 unsolicited messages.

**10. Control**

a. Control will be issued to each device using object=12 variation=1. A select command will be issued before an operate command is issued. The type of control will be PULSE ON, NULL or PULSE OFF, NULL.

**11. Default poll**

a. Will be any combination of class requests followed by a request for class 0. For instance, a default poll can be class 1, 2, 3, 0, class 1, 2, 0, class 1,0 or class 2,0. Static Data shall be reported to the DAS master in a class 0 poll.

b. When an Integrity poll is done, the RTU sends all the data (Static Data) that is configured on the RTUs for class 0. Digital Inputs: Object 01, Variation 01; Binary Outputs: Object 10, Variation 02; Binary Counters: Object 20, Variation 01; Frozen Binary Counters: Object 21, Variation 01; Analog Inputs: Object 30, Variation 02.

**12. Deadbands**

a. Each outstation shall support DNP deadbands. The deadbands will be downloaded to the RTU after a power fail or when the outstation comes online after being marked offline by the master using object=34 variation=1. Deadbands may be changed at the master by an operator and sent to the RTU on demand

b. There will be no counter deadbands.

**13. Download**

a. Each outstation shall allow configuration of its serial port interface parameters from the DAS master. These include: Delay after CTS before serial data is transmitted. Baud rate, DNP Data Link Frame size, etc.
b. Default analog deadbands shall be configurable from the master.

14. **Interface signals**
    a. By default there shall be no hardware handshake (no RTS/CTS handshake).
    b. Each outstation shall be able to assert its RTS signal and wait for CTS to be asserted before sending a data message to the radio modem.
    c. Each outstation shall deassert RTS when it no longer has data to send to the radio modem.

15. **Online/Offline processing at the RTU**
    a. When an RTU times out in an attempt to send data to the DAFE, it will retry.
        i. The timeout will be configurable from the master via download.
    b. After a configurable number of timeouts the RTU will mark itself offline.
        i. This number, normally 3, will be configurable from the master via download.
    c. When the RTU is offline, it will send the last unsolicited message until it receives a reply.
        i. The time interval on which the RTU sends this last unsolicited message is specific to this situation and is part of the RTU configuration. By default it will be 15 minutes.
        ii. The RTU shall not send Link Status commands in any situation because this may lead to channel congestion.
    d. When the RTU receives a reply to the last unsolicited message, it will mark itself online. It will then begin communicating normally.
    e. If the RTU should suffer data loss while it is offline, it will set the "Event Buffer Overflow" internal indication. The master station will then perform a default poll.

16. **Online/Offline processing at the DAFE**
    a. The DAFE will send a Link Status message to an RTU that has not communicated within a defined timeframe (15 minutes, configurable). Should an RTU not respond within a configurable timeout, the DAFE will mark the RTU offline. The Link Status message will continue to be sent on the same regular basis. When the RTU responds, the DAFE will issue a default poll to the RTU and force the RTU into unsolicited mode.

17. **DNP3 Collision Avoidance**

    Shall be configurable and shall be disabled in normal operation.

18. **Security Parameters**
    a. Secure Authentication will not be supported;
    b. Aggressive mode requests will not be accepted;
    c. Aggressive mode requests will not be issued.

# TECHNICAL SPECIFICATIONS FOR CROSS LINKED POLYETHYLENE INSULATED 3 CORE 11KV CABLES

1.00.00 **SCOPE:**

1.01.00 The scope of this package, covers the design, manufacture, stage inspection at works, inspection and testing of finished cables at manufacture's works, testing at independent test house, packing, transport and delivery to consignee's address of 6.35/11KV Three Core, aluminium conductor, XLPE insulated, screened, under ground Cables as per specified construction.

1.02.00 Technical Requirement: Three Core 6.35/11KV grade, 90°C rating heavy duty power cable with stranded compacted circular aluminium conductor shielded with extruded semi conducting compound, cross linked polyethylene insulated, shielded with extruded semi conducting compound and copper tape, shielded cores laid up with fillers, inner sheath of extruded PVC, Galvanized round steel wire Armour and PVC ST-2 overall sheath.

1.03.00 The cables should be suitable for use in solidly earthed system.

1.04.00 The Stranded Aluminium Conductor for different sizes of cable shall have the short circuit rating specified in this document, in schedule of requirement, schedule-I, Annexure TS-1.

2.00.00 **STANDARDS:**

2.01.00 The 11KV UG Cables shall, in general, meet the requirements of the latest edition of the Bureau of Indian Standards, (generally referred as IS) IS 7098 (Part-2) 1985. The cables manufactured to and meeting the testing requirements of international standards, like B.S.S. IEC or equivalent standards are also acceptable. The bidders shall enclose a copy of the equivalent international standard, in English Language, along with the Bid.

The extracts from IS 7098 (Part 2) are given in Annexure TS-3.

The cables and components in general shall meet the requirement Indian Standards with latest amendments or equivalent International Standards.

| | | |
|---|---|---|
| IS: 7098 (Part 2) | 1985 : | Specification for cross linked polyethylene insulated PVC sheathed cables |
| IS: 8130 | 1984 : | Specification for conductors for insulated Electric Cables |

| | | |
|---|---|---|
| IS: 3975 | 1979 : | Specification for mild steel wires, strips and tapes for armouring of cables. |
| IS: 10810 (Part 1 to 55) | 1984 : | Specification for test on cables |
| IS: 5831 | 1984 : | Specification for PVC insulation and sheath of electric cables |
| IS: 10418 | 1982 : | Specification for drums for electric cables |
| IS: 10462 (Part-I) | 1983 : | Fictitious calculation method for determination of dimensions of protective covering of cables: Part-I Elastomeric and thermoplastic insulated cables. |

2.02.00 11KV underground cables shall be manufactured to the highest quality, best workmanship with scientific material management and quality control. The Bidder shall furnish the quality plan, giving in details the quality control procedures/management system.

The successful bidder shall give sufficient advance notice to the purchaser of not less than fifteen days to arrange for stage inspection and inspection of quality assurance programme during manufacture, at the works.

3.00.00 **SYSTEMS DETAILS:**

General Technical Particulars:

| | | |
|---|---|---|
| 1) Nominal System Voltage (rms) (u) | - | 11 KV |
| 2) Highest System Voltage (rms) (um) | - | 12 KV |
| 3) Phase to Earth Voltage (uo) | - | 6.35 KV |
| 4) Number of Phases (for 3 core cables) | - | 3 |
| 5) Frequency | - | 50 Hz |
| 6) Variation in frequency | - | ±3% |
| 7) Type of Earthing | - | Solidly Earthed |
| 8) Basic impulse level (1.2/50 Micro Second Wave | - | 75 KV |
| 9) Total relay & circuit break operating time | - | 15-20 Cycles |
| 10) One minute power frequency withstand voltage | - | 28 KV |

4.00.00 **INSTALLATION CONDITIONS**:

a) Mostly directly buried in ground, partly in RCC/Hume pipes or stoneware pipes at road crossing in case of 3 core cables.

b) If more than one circuit is laid in the same trench, then laid in flat formation for 3 core cables.

c) Metallic coverings are connected solidly to earth at both ends of the run for 3 core cables and.

d) Normal depth of laying is 900 mm to 1000 mm (from top of round to entre of cable).

e) Nature of soil – Heterogeneous, sandy.

f) Soil resistivity: variable 18 to 100 Ohm – meter

g) Soil Thermal resistivity (assumed) 120 to 150 dig. C. Cm/w.

5.00.00 **CLIMATIC CONDITIONS**:

The climatic conditions at Bangalore City where these 11KV Cables will be installed are as under:

| | | |
|---|---|---|
| 1 | Location | Karnataka (28.58 N, 77.38E) |
| 2 | Altitude | 1000 M above MSL |
| 3 | Max. ambient air temperature | 45$^0$ C |
| 4 | Max. daily average air temp. | 38$^0$ C |
| 5 | Minimum ambient air temp. | 10$^0$ C |
| 6 | Ground temperature at depth of laying assumed | 35$^0$ C (Max.) |
| 7 | Isoceranic level | 5$^0$ C (Min.) |
| 8 | Avg. annual rainfall | As per IS:45 |
| 9 | Avg. number of rainy | 1450 Sq.mm. |
| 10 | Climatc | Tropical Moderately hot and humid |
| 11 | Soil | Normally dry. As per IS:1200 Part-I, 1974, likely hood of subsoil water at certain location at depth of burial of cables. |

6.00.00 **DESIGN CRITERIA**:

6.01.00 The cables that are covered in these specifications are intended for use in the Karnataka Power distribution system, under the climatic conditions and installation conditions descried in the technical specification.

6.02.00 Any technical feature, not specifically mentioned here, but is necessary, for the good performance of the product, shall be incorporated in the design. Such features shall be clearly brought out under Technical deviations schedule only in the offer made by the Bidder, giving technical reasons, and justifying the need to incorporate these features.

6.03.00 For continuous operation of the cables, at specified drawing, the maximum conductor temperature shall be limited to the permissible value as per the relevant standard, generally not exceeding 90$^0$C under normal operation and 250$^0$C under short-circuit conditions.

6.04.00 The cables in service will be subject to daily load cycles, of two peaks during day, morning peak and evening peak with reduced loading during the nights.

6.05.00 The materials used for sheaths shall be resistant to oils, acids and alkalies.

6.06.00 The cables shall be designed to withstand the thermo mechanical forces and electrical stresses during normal operation and transient conditions.

The Cables shall be designed to have a minimum useful life span of forty years.

Core identification: The core identification for 3 core cables shall be provided, by suitable means, like, by application of coloured stripes, or by numerals or by printing on the cores as per clause 13 of IS:7093.

7.00.00 **MANUFACTURE PROCESS, CROSS LINKING OF INSULATION:**

7.01.00 Cross linking of the insulation materials (pre compounded polyethylene) shall be conforming to IS:7098 (Part-II).

7.02.00 The conductor screen shall be of extruded semi conducting compound. The insulation screen shall consist of the nonmetallic part extruded semi conducting compound with non magnetic metallic port. The XLPE insulation and the shields for conductor and insulation shall be extended in one operation.

8.00.00 **MATERIALS:**

8.01.00 CONDUCTOR: The conductor shall be of stranded construction. The material for conductor shall consist of plain aluminium of H2 or H4 grade as per clause-3 of IS:8130/1984.

The number of wires in the conductor shall be not less than the appropriate minimum number given in Table-2 of IS:8130/1984.

8.02.00 INSULATION: The insulation shall be cross linked polyethylene conforming to the requirements given in Table-1 of IS:7098 Part-II.

8.03.00 SCREENING: The screening shall consist of semi conducting compound. The metallic screen for core shall consist of copper tape. The metallic screen with Armour shall be designed to carry the minimum short circuit rating for 1 second. (The design calculations shall be furnished by the tenderer).

8.03.01 The semi-conducting compound shall withstand the operating temperature of the cable and shall be compatible with the insulting materials.

8.04.00 **Filler and inner sheath for Multi Core Cables:**

For Multi Core cables, the interstices at the centre shall be filled with a non-hygroscopic materials.
The interstices around the laid up cores shall be covered with PVC compound type S.T-2. This will form the inner sheath for Multi Cores Cables.

8.05.00 **ARMOURING FOR 3 CORE CABLES:**

The armour shall be galvanized round steel wire, complying with the requirements of IS:3975. The Single Core Cables shall be armoured with hard drawing Aluminium round wire. A binder tape may be applied on the armour.

8.06.00 **OUTER SHEATH**:

The outer sheath shall consist of Poly Vinyl Chloride (PVC) compound, confirming to the requirements of Type ST-2 of IS:5831 suitable additive shall be added to give anti termite protection.

9.00.00 **CONSTRUCTION:**

The general constructional features of the cables shall be as follows:

a) **3 Core Cables**: Stranded, Compacted, Circular, Aluminium Conductor, Conductor Screen of extruded semi conducting compound, Cross linked polyethylene insulation, cross linked, shall be conforming to IS:7098 (Part-II).

Insulation screen consisting of non-metallic part of extruded semi conducting compound and the metallic part of copper tape(s).

Pressure Extruded PVC inner sheath
Armour (Galvanised Steel round wire)
Other PVC sheath with anti-termite treatment.

10.00.00 **CONDUCTOR:**

10.01.01 The conductor shall be stranded, compact, circular of aluminium wires of H2 or H4 grade plain aluminium wires.

10.01.02 The conductor shall be clean, uniform in size and shape smooth and free from harmful defects.

10.01.03 Not more than two joints shall be allowed in any one of the single wire forming every complete length of conductor and no joint shall be within 300 mm of any other joint in the same layer. The joint shall be made by brazing, silver soldering or electric or gas welding.

10.01.04 No joints shall be made in the conductor after it has been stranded.

10.02.00 **CONDUCTOR SCREEN**: The conductor screen shall be provided over the conductor consisting of extruded non metallic semi conducting compound.

10.03.00 **INSULATION**: The insulation shall be provided over the screened conductor with cross linked polyethylene, applied by extrusion and shall be of high quality, cross linked, shall be conforming to IS:7098 (part-2).

10.03.01 **THICKNESS OF INSULATION**: The average thickness of XLPE insulation shall not be less than the nominal value subject to the applicable tolerance as specified in table 2 of IS: 7098.

10.03.02 The insulation shall be applied to closely fit on the conductor screen, and it shall be possible to remove it without damaging the conductor.

10.03.03 The thickness of semi conducting screen over insulation should not be included in the thickness of Insulation.

10.04.00 **INSULATION SCREENING:** The Insulation screen shall be applied over the Insulations.

10.04.01 The Non-Metallic part of the Insulation screen shall consist of extruded Semi conducting compound.

10.04.02 The metallic part of the insulation screen shall consist of non-magnetic material, consisting of copper tape or tapes, and shall be applied over the non-metallic part. The metallic tape(s) shall be designed to carry the rated short circuit current.

10.05.00 **LAYING UP OF CORES:** For multi-core cables, the cores shall be laid together with a suitable right hand lay. The interstices at the centre shall be filled with a non-hygroscopic material.

10.06.00 **INNER-SHEATH FOR MULTI CORE CABLES:**

10.06.01 The cores shall be laid up with a suitable right hand lay and the interstices should be filled with PVC compound type ST2 conforming to IS:5831 or equivalent standard. The filling up of interstices shall be by pressure extrusion and this circular shape and shall bind the cores also.

10.06.02 The minimum thickness of the inner sheath shall conform to Table 3 of IS: 7098 (Part-2), 1985 or equivalent standard.

10.06.03 The inner-sheath shall be so applied that it fits closely on the laid up cores and it shall be possible to remove it without damage to the insulation cables.

10.07.00 **ARMOURING FOR 3 CORE CABLES:**

10.07.01 **Application**: The armour consisting of Galvanised steel wire shall be applied over the inner sheath for multi core cables.

10.07.02 The armour wires shall be applied as closely as possible.

10.07.03 The diameter of the galvanised round steel and hard drawn aluminium wires shall conform to IS: 7098 Part (2).

10.07.04 A binder tape may be applied on the armour.

10.07.05 The Joints in the armour wires shall be brazed/welded with joint surface and rendered smooth. The joints shall be staggered by at least 300 mm from the nearest joint in any other armour wire in the completed cable.

10.08.00 **OUTER SHEATH:**

10.08.01 The PVC outer sheath with anti termite treatment shall be extruded over the armouring for 3 core cables.

10.08.02 The colour of the outer sheath shall be black.

10.08.03 The thickness of outer sheath shall be not less than the minimum value specified in column 5 of Table 5 of IS: 7098 (Part-2) 1985.

10.09.00 **IDENTIFICATION:** The outer-sheath shall have the following information embossed or indented on it, the manufacturer's name or trade mark, the voltage grade, the year of manufacture and the letters "BESCOM". The identification shall repeat every 300/350 mm along with length of the cable.

11.00.00 **INSPECTION**:

11.01.00 Quality Control: The Bidder shall furnish a complete and detailed quality plan for the manufacturing process of the cable. All raw materials shall conform to relevant applicable standards and tested for compliance to quality and requirement.

During the manufacturing process, at all stages, inspections shall be made to check the physical and dimensional parameters, for verification to compliance to the standards.

11.02.00 The Bidder shall arrange, for inspection by the purchaser, during manufacture, if so desired by the purchaser, to verify the quality control process of the Bidder.

12.00.00 **TYPE TESTS**:

Not withstanding, that type test have been conducted earlier, the successful bidder the each member of consortium shall conduct all type tests as per IS:7098 part (2), 1985 with upto date amendments or equivalent international standard at his cost at either CPRI or any other accredited national laboratory/testing house and materials offered for inspection. Only after approval of the test reports from the purchaser materials shall be offered for inspection.

12.01.00 All type tests, routine, acceptance test shall be conducted in the presence of the purchaser, representative.

12.02.00 The successful Bidder shall give 15 days advance notice for inspections, and witnessing of tests by the purchaser or his representative.

12.03.01 The following type tests will be conducted on the cable.

a) Test on conductor
b) Test on armour wires
c) Test for thickness of XLPE insulation and inner and outer sheaths
d) Physical test on XLPE insulation
e) Physical test for outer sheath
f) Partial discharge test
g) Bending test
h) Di-electric power factor test
    (i) As a function of voltage
    (ii) As a function of temperature
i) Insulation resistance (Volume resistivity) test
j) Heating cycle test
k) Impulse withstand test
l) High voltage test
m) Flammability test

12.03.02 The following test shall be performed successively on the same test sample of completed cable, not less than 10 M in length between the test accessories.

a) Partial discharge test
b) Bending test followed by partial discharge test
c) Dielectric power factor as a function of voltage
d) Dielectric power factor as a function of temperature
e) Heating Cycle test, followed by dielectric power factor and function of voltage and partial discharge test.
f) Impulse withstand test

g) High voltage test.

12.04.00 **ACCEPTANCE TEST**:

12.04.01 The sampling plan for acceptance test shall be as per IS:7098 Part (2) 1985, Appendix 'A'.

12.04.02 The following shall constitute the acceptance test.

a) Tensile test for aluminium
b) Wrapping test for aluminium
c) Conductor resistance test
d) Test for thickness of insulation
e) Test for thickness of inner and outer sheath
f) Hot-set test for insulation
g) Tensile strength and elongation at break test for insulation and outer sheath
h) Partial discharge test (on full drum length)
i) High voltage test
j) Insulation resistance (volume resistivity) test.

12.05.00 **ROUTINE TEST**:

The following shall constitute routine tests:

a) Conductor resistance test
b) Partial discharge test on full drum length
c) High voltage test

13.00.00 **PACKING**:

13.01.01 The cables, as per specified delivery lengths, shall be securely wound/packed in non-returnable, well seasoned sturdy wooden drums, with strong reinforcements so as to withstand rough handling during transport by Rail, Road etc., The packing should withstand storage conditions in open yards. The cable drums shall conform to IS:10418-1982 or equivalent standard.

13.01.02 The drawing of cable drums with full detail shall be furnished, and got approved before dispatch.

13.02.00 **SEALING OF CABLE ENDS ON DRUMS**:

13.02.01 The Cable ends shall be sealed properly so that ingress of moisture is completely prevented.

13.02.02 The individual core endings shall be sealed effectively with water resistant compound applied over the core and provided with a heat shrinkable cap of sufficient length with adequate cushion space so

that the conductor does not puncture the cap in case of movement of the core during unwinding or laying. Before sealing, the semi conducting layer on the cores may be removed for about 2 mm at each end, to facilitate checking the insulation resistance from one end, without removing the sealing cap at the other end.

13.02.03 The three cores should have a over all heat shrinkable cap with adequate end clearance, and sufficient cushioning to prevent puncturing of the overall sealing cap due to stretching of the cores. The sealing cap shall have sufficient mechanical strength and shall prevent ingress of moisture into the cable.

13.02.04 **CABLE LENGTHS**: The cables shall be supplied in continuous lengths of 250/500 m in case of 3 core cables with a tolerance of ± 5% of drum length.

13.02.05 **QUANTITY TOLERANCE**: ±5% tolerance shall be allowed on the ordered quantity.

14.00.00 **MARKING**:

The packed a cable drum shall carry the following information, clearly painted or stenciled.

a) The letters "BESCOM"
b) Reference to Standard and ISI Mark
c) Manufacture's Name or trade mark
d) Type of Cable & Voltage grade
e) Number of cores
f) Nominal cores sectional area of conductor
g) Cable code
h) Length of cable on the drum
i) Direction of rotation
j) Gross weight
k) Country of Manufacture
l) Year of Manufacture
m) Purchase Order No. and Date
n) Address of consignee.

15.00.00 Cross sectional drawings of the cables giving dimensional details for each size of cable.

a) An illustrated literature on the cable giving technical information, on current ratings, cable constants, short circuit ratings, derating factors for different types of installation packing date weights and other relevant information.

## SCHEDULE-I

**Annexure: TS-1**

Schedule of requirement of 3 core armoured, 1 core armoured, 6.35/11KV (E) aluminium conductor, XLPE UG Cables

| Sl. No. | Cross sectional area of conductor (Sq.mm.) | Minimum current rating (Amps) in ground | Minimum short circuit rating (KA/1 Sec) | Delivery length per drum (± 5%) |
|---|---|---|---|---|
| 1 | 3 x 95 | 190 | 8.9 | 500 M |
| 2 | 3 x 240 | 315 | 22.5 | 250 M |
| 3 | 3 x 400 | 395 | 37.6 | 250 M |

The approximate current ratings in column 3 are for the following standard installation conditions.

| | | |
|---|---|---|
| i) | Maximum conductor temperature for continuous operation | 90 Deg. C. |
| ii) | Ambient air temperature | 40 Deg. C. |
| iii) | Ground temperature | 30 Deg. C. |
| iv) | Thermal resistivity of soil | 150 Deg. C. |
| v) | Depth of laying | 90 cm |
| vi) | Maximum conductor temperature at the end of short circuit | 250 Deg. C. |
| vii) | Method of installation | Installed single directly buried in ground |

## SCHEDULE-II

**Annexure: TS-2**

For the information of Bidder the important extracts from the Indian Standard IS:7098 (Part 2) 1985; "Specification for cross linked polyethylene insulated PVC sheathed cables are furnished here for their reference and to supply for the XLPE Cables called for in the bid specification

### TABLE-1:- PROPERTIES OF XLPE INSULATION

| Sl. No. | Property | Requirement |
|---|---|---|
| 1 | Tensile Strength | 12.5 N/Sq.mm. Min. |
| 2 | Elongation at break | 200 percent, Min. |
| 3 | **Ageing in air over**:<br>a) Treatment:<br>Temperature<br>Duration<br>b) Tensile Strength Variation<br>c) Elongation Variation | <br><br>135 ± 3 Deg. C<br>7 Days<br>± 25% Max.<br>± 25% Max. |
| 4 | **Hot Set**:<br>a) Treatment:<br>Temperature<br>Time under load<br>Mechanical stress<br>b) Elongation under load<br>c) Permanent Elongation (Set after cooling) | <br><br>200 ± 3 Deg. C<br>15 minutes<br>20 N/Sq.mm.<br>175% Max.<br>15% Max. |
| 5 | **Shrinkage**:<br>a) Treatment:<br>Temperature<br>Duration<br>b) Shrinkage | <br><br>130 ± 3 Deg. C<br>1 Hour<br>4% Max. |
| 6 | **Water absorption (gravimetric)**:<br>a) Treatment:<br>Temperature<br>Duration<br>b) Water absorbed | <br><br>85 ± 2 Deg. C<br>14 Days<br>1 Mg/Sq.mm. cm. Max. |
| 7 | **Volume resistivity**:<br>a) At 27 Deg. C<br>b) At 90 Deg. C | <br>$1 \times 10^{14}$ ohm-cm. Min.<br>$1 \times 10^{12}$ ohm-cm. Min. |

**TABLE-2:- NOMINAL THICKNESS OF INSULATION**

| Nominal Area of Conductor in Sq.mm. | Nominal thickness of insulation (ti) in mm. 6.35/11KV – 3 Core |
|---|---|
| 95 | 3.6 |
| 240 | 3.6 |
| 400 | 3.6 |

1) Thickness of insulation: The average thickness of insulation shall not be less than the nominal value (ti) specified in Table-2.

2) Tolerance on thickness of insulation: The smallest of the measured values of thickness of insulation shall not fall below the nominal value (ti) specified in Table-2 by more than 0.1 mm + 0.1 ti.

**TABLE-3:- THICKNESS OF INNER SHEATH (All dimensions in mm)**

| Calculated diameter over laid up cores (ref. IS 10462 Part 1, 1983) * | | Thickness of inner sheath (Min.) |
|---|---|---|
| Over | Upto & including | |
| (1) | (2) | (3) |
| - | 25 | 0.3 |
| 25 | 35 | 0.4 |
| 35 | 45 | 0.5 |
| 45 | 55 | 0.6 |
| 55 | - | 0.7 |

(*) Fictitious calculation method for determination, dimensions of protective coverings of cables: Part-I Electrometric and Thermoplastic Cables.

**TABLE-4:- DIMENSIONS OF ARMOUR GALVANIZED STEEL ROUND WIRES AND STRIPS**

**NOTE**: The dimensions of Galvanised steel wires or strips shall be as specified in Table-4.

| Calculated diameter for Armour (ref. IS 10462 Part 1, 1983) * | | Nominal thickness of steel strip | Nominal diameter of Round wire |
|---|---|---|---|
| Over | Upto & including | | |
| 1 | 2 | 3 | 4 |
| a) For all diameter in excess of 13 | | 0.8 | Nil |
| - | 13 | - | 1.40 |
| 13 | 25 | 0.8 | 1.60 |
| 25 | 40 | 0.8 | 2.00 |
| 40 | 55 | 1.4 | 2.50 |
| 55 | 70 | 1.4 | 3.15 |
| 70 | - | 1.4 | 4.00 |

**Note**: (a) and (b) indicate two methods of practice in the application of armouring.

* Fictitious calculation method for determination of dimensions of protective covering of cables: Part-I Electrometric & Thermoplastic Insulated Cables.

**TABLE-5:- THICKNESS OF OUTER SHEATH (All dimensions in mm)**

| Calculated diameter under the outer sheath (ref. IS:10462 Part 1, 1983) * | | Nominal thickness of steel strip | | Minimum thickness of outer sheath for Armoured Cables |
|---|---|---|---|---|
| Over | Upto & including | Nominal (ts) | Minimum | |
| 1 | 2 | 3 | 4 | 5 |
| - | 15 | 1.8 | 1.24 | 1.24 |
| 15 | 25 | 2.0 | 1.40 | 1.40 |
| 25 | 35 | 2.2 | 1.56 | 1.56 |
| 35 | 40 | 2.4 | 1.72 | 1.72 |
| 40 | 45 | 2.6 | 1.88 | 1.88 |
| 45 | 50 | 2.8 | 2.04 | 2.04 |
| 50 | 55 | 3.0 | 2.20 | 2.20 |
| 55 | 60 | 3.2 | 2.36 | 2.36 |
| 60 | 65 | 3.4 | 2.52 | 2.52 |
| 65 | 70 | 3.6 | 2.68 | 2.68 |
| 70 | 75 | 3.8 | 2.84 | 2.84 |
| 75 | - | 4.0 | 3.00 | 3.00 |

(*) Fictitious calculation method for determination of dimensions of protcctive covering of cables: Part-I Electrometric & Thermoplastic Insulated Cables.

**Note**:

Armoured Cables: The thickness of outer sheath shall be not less than the minimum value specified in column 5 of Table-5.

**Extracts from IS:7098 (Part 2), 1985, on Tests on Cables**:

i) Partial Discharge Test: The Partial discharge magnitude at test voltage equal to 1.5 Uo shall not exceed 20 PC.

ii) Bending Tcst: The diameter of test cylinder shall be (20D ±5) percent, where D is the overall diameter of the completed cable.

iii) Dielectric Power Factor Test:

a) Tan 'delta' as a function of voltage:

The measured value of tan 'delta' at Uo shall not exceed 0.004 and the increment of tan 'delta' bctwccn 0.5 Uo and 2 Uo shall not be more than 0.002.

b) Tan 'delta' as a function of temperature:

The measured value of tan 'delta' shall not exceed 0.004 at ambient temperature and 0.008 at 90 Deg. C.

iv) Heating Cycle (As per IS: 10810 Part 49):

After their cycle, the sample shall be subjected to dielectric power factor as a function of voltage and partial discharge test.

v) Impulse withstand test:

The impulse voltage level for cables of rated voltage 6.35/11KV is 75 KV. No breakdown of insulation shall occur during the test.

vi) High voltage test (As a type test/Acceptance test) for 6.35/11KV rated voltage cables:

The cable shall withstand without breakdown an A.C. Voltage equal to 3 Uo but not less than 17 KV (rms when applied to the sample between conductor and screen/metallic tape/armour, the voltage shall be gradually increased to the specified value and maintained for a period of 4 hours.

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BESCOM

# TECHNICAL SPECIFICATIONS
# FOR
# L.T. PVC Insulated Single Core Aluminium Lead Wire (Multi Strand).

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| Sl. No | Name of the Material | Page No |
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| 1 | Technical Specification for L.T. PVC Insulated Single Core Aluminium Lead Wire (Multi Strand). | |

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## Technical Specification for L.T. PVC Insulated Single Core Aluminium Lead Wire (Multi Strand).

1. The PVC Aluminium lead wire (multi strand) shall be of 1,100 volts grade and shall be single core. The cable shall be supplied in coils of 100 Mtrs. Length.

2. The lead wire (multi strand) shall be manufactured, tested and supplied as per IS-694 of 2010 with latest amendments if any.

3. The conductors shall be composed of Aluminium wires complying with IS-8130 of 1984 with latest amendments, if any. The conductor particulars shall be as noted below.

**Note:** The conductor shall satisfy the requirement of resistance as per IS-8130 and also the nominal cross section specified below:

| Sl. no | Cable | Conductor | Weight of Aluminium in kgs/100m | Remarks |
|---|---|---|---|---|
| 1. | 50Sq. mm | 19/1.83mm | 14.40 | Un Sheathed |
| 2 | 70 Sq.mm | 19/2.17mm | 20.17 | Un Sheathed |
| 3 | 95 Sq mm | 19/2.52mm | 27.40 | Un Sheathed |
| 4 | 120 Sq mm | 37/2.03mm | 34.58 | Un Sheathed |
| 5 | 150 Sq mm | 37/2.27mm | 43.22 | Un Sheathed |
| 6 | 185.0 Sq .mm | 37/2.52 mm | 53.30 | Un Sheathed |
| 7 | 240.0 Sq .mm | 37/2.85 mm | 70.30 | Un Sheathed |

(The weights of Aluminium conductor given above are as per IEEMA circular)

4. The conductor shall be provided with PVC insulation applied by extrusion and the PVC compound shall be type 'A' of IS5831 of 1984 with latest amendments, if any and shall satisfy test requirements for PVC insulation stipulated in IS 5831.

5. The colour of the cable and sheath shall be Black.

6. **Packing & Marking**:

6.1 The Marking shall be as per IS: 694 of 2010 with the following details;

**A** **On the Lead Wire:**

i) Reference of Indian Standard IS 694;
ii) Manufacturer's name, Brand name or Trade-Mark;
iii) The letter **"BESCOM".**
iv) Year of manufacture
v) Type of cable and Voltage Grade;

vi) Nominal cross sectional area of conductor;
vii) Cable code;
viii) Colour of core;
ix) The word 'suitable for outdoor use' ;

The printing, indentation or embossing shall be done on the insulation. Thc distance between any two consecutive printings, indentations or embossing shall be not morc than 1m.

**B** **<u>On the Drum/ Reel:</u>**

i) Length of thc cable on the reel, drum or coil;
ii) Direction of rotation of drum (by mcans of arrow);
iii) Approximate Gross Weight in kgs;
iv) Year of manufacture;
v) Purchase Order reference and Date.

6.2 The packing of the cable reel or drum shall also be marked with the standard markings and BESCOM Purchase order reference.

7. Test Certificates:-

a) All the type test certificates on conductors, PVC insulation etc. stipulatcd in IS 694 of 2010 with latest Amendments, if any shall be submitted for approval.
b) In case of an order, all the acceptance tests stipulated in IS 694 shall be conducted in presencc of BESCOM representative.
c) Routine tests shall be conducted and test reports in the form of test certificates signed by a responsible officer of the firm shall be submitted to this office for approval before dispatch of the material.

**General Manager El,**
**Procurement, BESCOM**

# TECHNICAL SPECIFICATION FOR SPIRAL EARTH ELECTRODE

**1.0** This specification is for Spiral/ Coil earthing for non current carrying parts of DP structures in a distribution system.

**2.0 Design & Construction**

**2.1** The material used shall be No.8 SWG GI Wire or higher size closely wound 115 turns as per drawing SIC/MISC/001 and SIC/DL/004.

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**BANGALORE ELECTRICITY SUPPLY COMPANY LIMITED**

# TECHNNICAL SPECIFICATION FOR GAPLESS METAL OXIDE DISTRIBUTION TYPE SURGE ARRESTERS WITH POLYMERIC HOUSING FOR USE IN 11KV SYSTEM

## 1.0 SCOPE

This specification covers design, manufacture testing and supply of gapless Metal Oxide Distribution type surge arresters with polymeric housing for usc in thc 11kV overhead distribution system, to protect electric power systems from expose to over voltages which might over stress the dielectric strength of equipment used. Over voltages can be caused by lightning strokes (lightning over voltages). Switching and circuit breaking (Switching over voltages) or certain load flow conditions (Temporary over voltages).

## 2.0 APPLICABLE STANDARDS

### 2.1 Standards

Following Indian/International standards, which shall mean latest revision, with amendments/changes adopted and published, unlcss specifically stated otherwise in the specification, shall bc referred while accessing conformity of polymeric surge arresters with these spccifications.

**2.1.1** In the event of supply of polymeric surge arresters conforming to standards other than specified, the Bidder shall confirm in his bid the these standards are equivalent or better to those specified. In case of award, salient features of comparison between the standards proposed by the bidder and those specified in this document will be provided by the supplies to establish equivalence.

| Sl. No. | Indian standard | Title | International Standard |
|---|---|---|---|
| 1 | IS 15086 part-4 2017 | Polymeric surge arresters, Part -4: Surge arresters without gapes for A.C. Systems overhead lines above 1000V | IEC:60099-4 2014, Edition-3 or latest if exists |
| 2 | | Polymeric surge arresters – 5 selection & application recommendations | IEC:6009-5 , 2013 or latest if exists |
| 3 | | Polymer burning behavior | IEC:60707 & UL94 |
| 4 | IS:13134 | Guide for the selection of Polymeric surge arrestor with respect of to | IEC:60815 |

| | | | |
|---|---|---|---|
| | | polluted conditions | |
| 5 | | Thermal Mechanical performance test and mechanical performance test on Polymeric surge arrestors | IEC:60575 |
| 6 | | Hydrophobicity Classification Guide | STRI guide:1.92/1 |
| 7 | | Radio interference characteristics of overhead power lines and high voltage equipment | CISPR:18-2 Part 2 |
| 8 | IS:8263 | Methods of RI Test of HV surge arresters | IEC:60437 |
| 9 | | Standards for surge arresters-composite – Distribution Dead – end Type | ANSI C29.13 |
| 10 | | Hot dip zinc coating on structural steel & other allied products | ISO:1459 ISO:1461 |
| 11 | IS:2629 | Recommended practice for Hot, Dip Galvanization for iron and steel | ISO:1461(E) |
| 12 | IS:6745 | Determination of Weight of Zinc coating on Zinc coated iron and steel articles | ISO:1460 |
| 13 | IS:3203 | Methods of testing of local thickness of electroplated coatings | ISO:2178 |
| 14 | IS:2633 | Testing of Uniformity of coating of Zinc Coated articles | |
| 15 | | Standard specification for glass Fiber standards | ASTM D 578-05 |
| 16 | | Standard test method for Compositional analysis by thermogravimetric. | ASTM E 1131-03 |
| 17 | IS:4699 | Specification for refined secondary Zinc | |

## 3.0 Technical Description of Polymeric Surge arresters

### 3.1 Service condition

The polymeric surge arresters to be supplied shall be suitable for satisfactory continuous operation under conditions as specified below:

Maximum ambient temperature : 50°C
Minimum ambient temperature : -5° C
Relative humidity : 0 to 1005

### 3.2 System Parameters

The arresters must be able to operate under the system parameters mentioned in this specification:

| | |
|---|---|
| Nominal voltage system kV(rms) | 11kV |
| Frequency | 50Hz |

| | |
|---|---|
| Grounding of neutral | Solidly |
| Temporary over voltage (Earth fault factor) | 10.4kV rms for 10sec. |
| Highest system voltage kV(rms) | 12kV |
| Short circuit levels | 16kA |
| Equipment Insulation withstand level | 75kV |
| Wet Power Frequency withstand voltage | 38kV |

**3.3 Surge arresters requirements:**

**a) Mechanical requirements:**

| | |
|---|---|
| Creepage length | 300mm(Min.) |
| Pull strength | 1000N (Min.) |
| Cantilever load | 75Nm(Min.) |
| Torsion | 30Nm(Min.) |

**b) Electrical requirements:**

| | |
|---|---|
| Arrester Max. Continuous Operating voltage Uc | 8kV rms |
| Arrester Rated voltage Ur | 12kV rms, with distribution medium - DH class as per latest Edition |
| Arrester Class / Nominal discharge current | DL / In=10kA |
| Min repetitive charge transfer capability : Qrs | Minimum 0.4C |
| Max. Lightning Impulse residual voltage @ In | 29kVp |
| Max. Steep Impulse residual voltage @ In | 32kVp |
| Minimum Thermal Charge rating for two impulses | Qth : 1.1C |
| TOV values | 1 secs : kV<br>10 Sec : kV<br>100 Sec : kV |
| Surge arrester housing Insulation withstand voltages<br>i) Lightning Impulse (Dry)<br>ii) Power Frequency (Wet) | As per IEC 60099-4 / IS 15086 Part-4 Standard |
| High current impulse withstand (4/10 micro second value) kA (peak) | 100kA |
| Pressure relief current<br>High current<br>Low current | 16kA ,<br>High & low currents as per IEC 60099-4 / IS 15086 Standards |
| Partial Discharge | ≤ 10 pC |
| Pollution Condition | Heavy |

| | |
|---|---|
| Minimum Bending load (kgm)<br>SSL<br>SLL<br>Terminal torque | <br>50kgf<br>25kgf<br>2.5kgm |

**3.3.1** The polymeric surge arresters shall be suitable for 3, 50Hz, effectively earthed 11kV O/H distribution system in a heavily polluted atmosphere.

**3.3.2** Bidder must be an indigenous manufacture and supplier of polymeric surge arresters of rating 11kV or above OR must have developed proven in house technology and manufacturing process for polymeric surge arresters of above rating OR possess tcchnical collaboration/association with a manufacture of polymeric surge arresters of rating 11kV or above. The Bidder shall furnish necessary evidence in support of the above along with the bid, which can be in the form of certification from the utilities concerned, or any other documents to the satisfaction of the owner.

**3.3.3** Polymeric surge arrcsters shall have sheds with good self - cleaning properties, surge arresters shed profile, spacing, projection etc., and selection in respect of polluted conditions shall be generally in accordance with the recommendation of IEC-60815/IS:13134.

**3.4 Dimensional Tolerance of polymeric surge arresters**

The tolerance on all dimensions e.g. diameter, length and creepage distance shall be allowed as follows:

$\pm$ (0.04d + 1.5)mm when d<300 mm.

$\pm$ (0.025d + 6) mm when d>300 mm.

Where, d being the dimensions in millimeters for diameter, length or creepage distance as the case may be.

However, no negative tolerance shall be applicable to creepage distance.

**3.5 Interchangeability**

The surge arresters including thc end filling connection shall be of standard design suitable for use with the hardware fittings of any make conforming to relevant IEC/IS standards.

**3.6 Corona and RI Performance**

All surface arresters shall be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The surge arresters and metal parts shall be so designed and manufactured that it shall avoid local corona formation and not

generated any radio interference beyond specified limit under the operating conditions.

**3.7 Maintenance**

**3.7.1** The surge arresters offered shall be suitable for use hot line maintenance technique so that usual hot line can be carried out with ease, speed and safety.

**4.0 BASIC FEATURES:**

**4.1 Design and construction**

Surge arresters having one or several non-linear metal oxide resistor with highly non-linear voltage – current characteristics, connected in series, but having no integrated series or parallel gaps.

The surge arresters shall be of cage design/ warp design

**Cage:** Using FRP rods which can be used as mechanical supporting part to accommodate the stack of MO elements. The Silicon rubber insulation is then moulded directly on to the MO elements without any internal gas volume left.

The MO elements is safely kept in place by the cage together with the high compressive force and they are embedded in to silicon rubber. Thus, the active part is almost protected from mechanical impact resulting in high transports safety.

**Wrap design**: The Mechanically supporting part of the housing is formed by a wrapped FRP using Prepeg glass rovings or pre-impregnated bands that are wound around the MO resistor stack and cured. The resulting wrap, surrounding the varistor stack, to have open "windows" moulded with silicone rubber for relieving the short circuit. Shall be void free construction.

Since, there is a direct contact of the MO elements with the polymer material in cage and wrap designs, heat produced by the MO elements is more easily dissipated through the housing into the environment. This increases thermal stability and follows utilize more than MO elements with respect to electrical stress.

**4.1.1 Cage:**

It shall be a glass –fiber reinforced epoxy resin rod of high strength (FRP rod). Glass fibers and resin shall be optimized in the FRP rod. Glass fibres shall be Boron free electricity corrosion resistant (ECR) glass fiber or boron free E-Glass and shall exhibit both high electrical

integrity and high resistance to acid corrosion. The matrix of the FRP rod shall be Hydrolysis resistant. The FRP rod shall be manufactured through pultrusion process. The FRP rod shall be void free.

### 4.1.2 Housing (Sheath)

The surge arrester with housing made of silicon Rubber (SR) material without air voids neither between the housing and the metal oxide resistors nor the housing itself. Arresters must have directly moulded, housing FRP rod shall be covered by a seamless sheath of a silicon rubber compound of thickness of 3mm minimum.

It should protect the FRP rod/ FRP tapes shall be covered against environmental influences, external pollution and humidity. It shall be extruded or directly molded on the core and shall have chemical bonding with the FRP rod. The strength of the bond shall be greater than the tearing strength of the polymer. Sheath material in the bulk as well as in the sealing/bonding area shall be free from voids.

### 4.1.3 Weather Sheds

The weather sheds made of silicon rubber shall be firmly bonded to the sheath, vulcanized to the sheath or molded as part of the sheath and shall be free from imperfections. The weather sheds should have silicon content of minimum 30% by weight. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The interface, if any, between sheds and sheath (Housing) shall be free from voids, and shall be resistant against UV- radiation as well as tracking.

Silicone Rubber (RTV – 2/LSR) shall have inherent burning behavior, shall pass the test of IEC 60707 and UL94 with the highest class Vo, i.e. self- extinction within 10 seconds without development of burning drops. The limiting oxygen index(LOI) is greater the 35% i.e. to continue burning after inflaming an oxygen content of more then 355 is required.

### 4.1.4 End Fittings

The End fittings transmit the mechanical load to the core. They shall be made of spheroidal graphite cast iron, malleable cast iron or forged steel or aluminium alloy. They shall be connected to the rod by means of a controlled compression technique. The gap between fitting and sheath shall be sealed by a flexible silicone rubber sealing performance between housing i.e. seamless sheath and metal connections. The sealing must be moisture proof. End fitting shall be of type to suitable

for vertical and horizontal mounting and should match all mechanical and electrical requirements specified for the arrester. Terminals shall be made of M10 bolts allow the connections of line and ground leads.

**4.1.5 Disconnector**

**Disconnector withstand**

When an arrester is fitted or associated with a disconnector, this device shall withstand, without operating, each of the following tests:

a. Test to verify the retitive charge transfer rating, Qrs (see clause 8.5.2 of IS 15086(part 4):2017).
b. Operating duty test with rated values of thermal charge rating, Qth (see clause 8.7.2 of IS 15086(part 4):2017).
c. Mechanical tests on agreement between manufacturer and user (see NOTES 1 and 2 8.9.4.1 of IS 15086(part 4):2017).

**Disconnector operation**

Three values of current according to clause 8.9.3 of IS 15086(part 4):2017.There shall be clear evidence of effective and permanent disconnection by the device.

**5.0 Workmanship**

**5.1** All the materials shall be of latest design and conform to the best engineering practices adopted in the high voltage field. Bidders shall offer only such surge arrester as are guaranteed by them to be satisfactory and suitable for continued good service in power Distribution System.

**5.2** The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners.

**5.3** The design of the surge arrester shall be such that stresses due to expansion and contraction in any part of the arrester shall not lead to deterioration.

**5.4** The MO shall be sound and free of cracks and voids that may adversely affect the arrester.

**5.5** Weather sheds shall be uniform in quality. They shall be clean, sound, and smooth and shall be from defects and excessive flashing at parting lines.

**5.6** End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively sealed to prevent moisture ingress; effectiveness of sealing system must be supported by test documents. Al. surfaces of the metal parts shall be perfectly smooth without projecting points or irregularities, which may cause

corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

**5.7** All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 610gm/sq.m or 87mm thickness and shall be in accordance with the requirement of IS:4759. The zinc used for galvanizing shall be of purity 99.5% as per IS:4699. The zinc coating shall be uniform, adherent, smooth, reasonably bright, continuous and free from imperfections such as flux, ash rust strains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand of least four successive dips each lasting for one(1) minute duration under the standard test. The galvanizing shall be carried out only after any machining.

**6.0 Equipment Marking:**

**6.1** Each surge arresters unit shall be legibly and indelibly marked with the following details as per IEC- 60099-4, Latest Edition

(a) Month & Year of manufacture.
(b) Manufacturer's name/Trade mark, Model no and identification Serial No.
(c) Maximum Continuous operating voltage.
(d) Rated Voltage
(e) Nominal discharge current and class of arrester
(f) Repetitive Charge Transfer Capability in Columbs
(g) Pressure relief class : Type A or Type B, Rated short circuit current in kA rms
(h) Cantilever strength-SSL/SLL/Terminal torque
(i) Total leakage and resistive leakage current-Ir at MCOV value .(before installation)
(j) Purchase order reference

6.2 Each ZnO element's Aluminum sprayed surface shall be printed with information like:

a. Batch No.
b. Designation with thermal energy and charge transfer rate
c. Rating & MCOV
d. Nominal Discharge current
e. AC reference voltage measured at reference current
f. Residual voltage measured at nominal discharge current
g. Type of the block (design code given by manufacturer)
h. Manufacturer's name

The manufacturers may use QR code printed on the block in case of size limitation.

## 7.0 Bid Drawing

**7.1** The Bidder shall furnish full description and illustration of the material offered.

**7.2** The Bidder shall furnish along with the bid the outline drawing (3 copies) of arrester unit including a cross sectional view.

**7.3** After placement of award, the supplier shall submit full dimensioned manufacturing arrester drawings containing all the details in four (4) copies to the owner for approval. After getting approval from owner and successful completion of all the type tests, the supplier shall submit 10 more copies of the drawing to the Owner for further distribution and field use.

**7.4** After placement of award the supplier shall also submit fully dimensioned arrester crate drawing for different type of surge arresters, drawing (cross sectional view) of ZnO elements used inside arrester for approval of the owner.

The drawings shall be submitted with the following details:

For the arrester:

a) Manufacturer name
b) Class and model no of arrester
c) Rated and MCOV of arrester
d) Nominal discharge current
e) Pressure relief type and current (High current and low current)
f) Thermal energy rating: $W_{th}$
g) Repetitive Charge Transfer rating: $Q_{rs}$.

For the ZnO element:

a. Batch No.
b. Designation with thermal energy and charge transfer rate
c. Rating & MCOV
d. Nominal Discharge current
e. AC reference voltage measured at reference current
f. Residual voltage measured at nominal discharge current
g. Power loss value measured at continuous operating voltage
h. Type of the block (design code given by manufacturer)
i. Manufacturer's name

## 8.0 Tests and Standards

Polymeric surge arrester offered shall be manufactured with the same configuration and raw materials as used in the Surge arrester for which design and type test reports are submitted. The manufacturer shall submit a certificate for the same. The design & type test reports submitted shall not be more than 5 years old.

### 8.1 Design Tests

Manufacture should submit test reports for design Tests as per relevant clauses of IEC-60099-4 / IS15086 Part-4 Latest Editions & IEC – 60099-5 / IS 15086 Part-5 latest Editions Standards along with the bid. Additionally following tests shall be carried out or reports for the tests shall be submitted after award of contract:

UV test: The test shall be carried out in line with clause 7.2 of ANSI IC29.13.

## 8.2 Type Tests

The following type tests shall be conducted on a suitable number of individual Surge arrester, componcnts and materials.

**8.2.1** The bidder shall submit type test reports as per IEC 60099-4 / IS along with the bid. Additional type tests as required above shall be carried out by the manufacturer after award of contract for which no additional charges shall be payable. In case the tests have already been carried out, the manufacturer shall reports for the same

| Sl No. | Description of type test | Test procedure / Clause as per standards IEC 60099-4 / IS 15086 Latest Editions |
|---|---|---|
| 1. | Residual Voltage Tests on elements<br>• Steep Current Impulse residual voltage<br>• Lightning Current Impulse 8/20 µS.<br>• Switching impulse residual voltage test | 8.3 / 10.8.3<br>8.3.2 / 10.8.3.2<br>8.3.3 / 10.8.3.3<br>8.3.4 / 10.8.3.4 |
| 2 | Test to verify Long term thermal stability under continues operating voltage / Accelerated ageing test | 8.4 / 10.8.4 |
| 3. | Repetitive charge transfer rate | 8.5 / 10.8.5 |
| 4. | Heat Dissipation behavior of Test sample | 8.6 / 10.8.6 |
| 5. | Operating duty test on prorated sections / Switching surge energy rating (IEEE) | 8.7 / 10.8.7 |
| 6. | Power frequency vs time test / TOV test | 8.8 / 10.8.8 |
| 7 | Repetitive charge transfer test on Disconnectors | 8.9.2/ 10.8.9.2 |
| 8 | Operating duty test on Disconnectors | 8.9.2 / 10.8.9.2 |
| 9 | Disconnector Operation Tests | 8.9.3/ 10.8.9.3 |
| 10 | Short circuit test | 8.10 / 10.8.10 |
| 11. | Bending moment test | 8.11 / 10.8.11 |

| | | |
|---|---|---|
| 12 | Environmental test on arresters | 8.12 / 10.8.12 |
| 13 | Weather ageing test on polymer arresters | 10.8.17 |
| 14. | Tests for arrestor disconnectors | Clause 4.1.5 of Technical specifications |

**8.2.2** It shall be the option of the owner to accept the surge arresters based on type test reports submitted by the manufacturer. The owner shall be free to repeat the type tests & may witness the same.
For the purpose of facilitating the type test, the bidders may quote test charges separately.

**8.2.3** All the type test given in Clause No:8.2 in addition to routine and acceptance test shall be carried out on surge arresters along with hard ware fittings wherever required.

**8.3** Acceptance (Sample) Tests

**8.3.1** For Surge Arrester

| | | |
|---|---|---|
| a) | Measurement of Power Frequency voltage at Reference Current | Clause 9.2.1 As per IEC:60099-4 IEC:2014 |
| b) | Lightning impulse residual on the complete arrester | |
| C) | Internal partial discharge test | |
| d) | Repetitive charge transfer rate with minimum Qrs = 0.4 C | |

## 8.4 Routine Tests

| | | |
|---|---|---|
| A) | Measurement of reference voltage (Uref) (See 3.35 and 6.2) | Clause 9.1 As per IEC:60099-4 IEC:2014 |
| b) | Residual voltage test | |
| c) | Internal partial discharge test | |
| d) | Current distribution test for multi-column arrester | |
| e) | For arrester units with sealed housing, a leakage check shall be made on each unit by any sensitive method adopted by the manufacture. | |

## 8.5 Tests During Manufacture

Following tests shall be also be carried out on all components if applicable.

| | |
|---|---|
| a) | Chemical analysis of zinc used for galvanizing |
| b) | Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings. |
| c) | Chemical analysis, hardness tests and magnetic particle inspection for forgings |

**8.6 Sample batch for Type Testing**

**8.6.1** The bidder shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Owner. The bidder shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

**8.7** Additional Tests

**8.7.1** The Owner reserves the right at his own expenses, for carrying out any other test(s) of reasonable nature carried out at supplies premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material comply with the specifications.

**8.7.2** The Owner also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at supplies premises or at any other test center. In case of evidence of non compliance, it shall be binding on the part of the supplier to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the owner.

**8.8 co-ordination For Testing**

**8.8.1** The supplies shall have to co-ordinate testing of surge arresters with hard ware fittings to be supplied by other supplier and shall have to guarantee overall satisfactory performance of the surge arresters with the hardware fittings.

**8.8.2** The bidder shall intimate the owner about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance of the scheduled date of testing which the owner will arrange to depute his representative to be present at the time of carrying out the tests

**8.9 Quality Assurance Plan**

**8.9.1** The successful bidder shall submit following information to the owner:

**8.9.1.1** Test certificates of the raw materials and brought out accessories

**8.9.1.2** Statement giving list of important raw materials, their grades along with manes of sub – supplies for raw materials, list of standards according to which the raw materials are tested. List of tests normally carried out on raw materials in presence of bidders representative.

**8.9.1.3** List of manufacturing facilities available along with Routine test facilities.

**8.9.1.4** Level of automation achieved and lists of areas where manual processing exists.

**8.9.1.5** Lists of areas in manufacturing process, where stage inspections are normally carried out for quality control and details of such tests and inspections.

**8.9.1.6** List of testing equipments available with the bidder for final testing of equipments along with valid calibration reports.

**8.9.1.7** The manufacture shall submit manufacturing quality plan(MPQ) for approval & the same shall be followed during manufacture and testing,

**8.9.2** The successful bidder shall submit the routine test certificates of brought out raw material/accessories and central excise passes fior raw material at the time of inspection.

**8.10 Guarantee**

The Supplier of surge arresters shall guarantee overall satisfactory performance of the surge arresters.

**8.11.1** At least three copies of type test reports shall be furnished. One copy shall be returned duly certified by the owner. Only after which the commercial production of the concerned material shall start.

**8.11.2** Copies of acceptance test reports shall be furnished in at least three(3) copies. One copy shall be returned duly certified by the owner, only after which the materials shall be dispatched.

**811.3** Record of the acceptance test reports shall be maintained by the supplier. These shall be produced for verification as and when desired by the owner.

**811.4** Test certificates of test during manufacture shall be maintained by the supplier. These shall be produced for verification as and when desired by the owner.

**9.0 Inspection**

**9.1** The Owner's representative shall at all times be entitled to have access to the works and all places of manufacture, where surge arresters and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the supplier's and sub-supplier's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

**9.2** The material for final inspection shall be offered by the supplier only under packed condition. The Owner shall select samples at random from the packed lot for carrying out acceptance tests. The lot offered for

inspection shall be homogenous and shall contain surge arresters manufactured in 3-4 consecutive weeks.

**9.3** The supplier shall keep the owner informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

**9.4** No material shall be dispatched from its point manufacture before it has been satisfactory inspected and tested unless the inspection is waived off by the owner in writing. In the later case also material shall be dispatched only after satisfactory testing specified here in has been completed.

**9.5** The acceptance of any quantity of material shall in way relieve the supplier of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such materials are later found to be defective.

**10.0 Packing**

**10.1** All surge arresters shall be packed in strong corrugated box of min.7 ply duly palette or wooden crates. The gross weight of the crates along with the material shall not normally exceed 100kg to avoid handling problem. The crates shall be suitable for outdoor storage under wet climate during rainy season.

**10.2** The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.

**10.3** Suitable cushioning protective padding or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.

**10.4** All Packing cases shall be marked legibly and correctly so as ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty or illegible markings. Each wooden case/crate/corrugated box shall have all markings stencilled on it in indelible ink.

**10.5** The bidders shall provide instructions regarding handling and storage precautions to be taken at site.

**Tests on surge arresters units**

1. **RIV Test (Dry)**

   The surge arresters string along with complete hardware fittings have a radio interference voltage level below 100 microvolts at one MHZ when subjected to 50 Hz AC voltage of 10kv class surge arresters under dry condition. The test procedure shall be in accordance with

IS:8263/IEC:437/CISPR 18-2. This test is applicable for surge arresters > 72.5kV

**2. Brittle Fracture Resistance Test**

Brittle fracture test shall be carried out on naked rod along with end fittings by applying "IN HNO3 acid" (63 g conc. HNO3 added to 937 g water) to the rod. The rod should be held at 80% of SML for the duration of the test. The rod should not fail within the 96 hour test duration. Test arrangement should ensure continuous wetting of the rod with Nitric acid.

**3. Recovery of Hydrophobicity & Corona test.**

The test shall be carried out on 4mm thick samples of 5cm x 7cm.

i) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the Hydrophobicity classification in line with STRI guide for Hydrophobicity classification. Dry the sample surface.

ii) The samples shall subjected to mechanical stress by bending the sample over a ground electrode. Corona is continuously generated by applying 12kv to a needle like electrode place 1mm above the sample surface. The test shall be done for 100 hrs.

iii) Immediately after the corona treatment, spray the surface with water and record the HC classification. Dry the surface and repeat the corona treatment as at clause 2 above. Note HC classification. Repeat the cycle for 1000 hrs or unit HC of 6 or7 obtained. Dry the sample surface.

iv) Allow the sample to recover and repeat hydrophobicity measurement at several time intervals. Silicone rubber should recover to IIC1 -- HC 2 within 24 hours, depending on the material and the intensity of the corona treatment.

**4. Chemical composition test for Silicon content.**

The content of silicon in the composite polymer shall be evaluated by EDX (energy Dispersion X-ray) Analysis or Thermogravimetric analysis. The test may be carried out at CPRI or any other NABL accredited laboratory.

## Annexure - B

## Guaranteed technical Particulars of surge arresters

**Name of the manufacture:**

**Address of works:**

| Sl.no | Description | Unit | |
|---|---|---|---|
| 1. | Arrester Type or Designation | Kvrms | |
| 2. | Arrester continuous operating voltage Uc | Kvrms | |
| 3. | Arrester rated voltage Ur | KA | |
| 4. | Nominal discharge current in | KA | |
| 5. | Arrester Class | DH/DM/DL | |
| 6. | High current discharge current 4/10us | KA | |
| 7. | Repetitive Charge Transfer ratc | C | |
| 8. | Repetitive Charge Transfer rate duration | µs | |
| 9 | Temporary overvoltage capability (kV rms) | 0.1 sec<br>1.0 sec<br>10 sec<br>100 sec | |
| 10. | Rated short circuit current Isc | | |
| | a. pressure relief class | | |
| | b. High current | kA | |
| | c. Low current | A | |
| 11. | Pull strength | N | |
| 12. | Cantilever strength | Nm | |
| 13. | Torque strength | Nm | |
| 14. | Total height of arrester | mm | |
| 15. | Creepage length | mm | |
| 16. | Flashover distance | mm | |
| 17. | Housing Lightning impulse 1,2/50 Us withstand lcvcl | kVp | |
| 18. | Housing Wet power frequency withstand level | kVrms | |

| | | | |
|---|---|---|---|
| 19. | Housing type | | |
| 20. | Housing material | | |
| 21. | Colour of Housing | | |
| 22. | Void – free Design (state) | Yes/No | |
| 23. | Bonding/Interfacial sealing(State) | Yes/No | |
| 24. | Reference current | mA | |
| 25. | Reference Voltage range(Min/Max) | kV | |
| 26. | Max. partial discharge level | pC. | |
| 27. | TOV curve enclosed? | Yes/No | |
| 28. | Arrester will be able to operate under the system parameters mentioned is S3 | Yes/No | |
| 29. | Maximum residual voltage of arrester for: Lightning current impulse 8/20us at<br>5kA<br>10kA<br>20kA<br>Step lightning current impulse 1/10 us at nominal discharge current In | kV | |
| 30. | Minimum recommended centre to centre distance between arresters | mm | |
| 31. | Minimum recommended distance from centre of arrester to nearest grounded object. | mm | |
| 32 | Each ZnO block Dimension | | |
| 32 | Date of last Type test | | |

Date:

Place:

Signature

(Name)

(Designation)

(296)

# TECHNICAL SPECIFICATION FOR RABBIT ACSR CONDUCTOR

**1.0 SCOPE:**

This specification covers manufacture, testing at manufacturer's works and supply of Rabbit ACSR conductor.

2.0 The basic technical and other particulars of the equipment and the various components are specified in the following sections and tender schedule.

**3.0 CONSTRUCTION:**

3.1 ACSR Conductor: The conductor shall comply in all respects with the latest edition of IS-398 (Part-II) 1996 with its latest amendment. The Aluminium wires used in the manufacture of the conductor shall be of the highest electrical quality and free from scratches, die marks and other surface imperfections. They shall be reinforced with a central core of galvanized high tensile steel wire having negligible sulphur and phosphorous contents.

3.2 The steel wire shall not be subject to any heat treatment after being galvanized. The zinc coating of steel wires shall be smooth and of uniform thickness. There shall be no bare spots owing to adherence of scales or other causes.

3.3 Joints in wires: Joints in the individual Aluminium, wires are permitted but no two such joints shall be within 15 meters apart in the complete stranded conductors. There should be no joints in the galvanized steel wire except those made in the base rod or wire before final drawing forming the core of steel reinforced Aluminium.

3.4 The resistance of the individual Aluminium wire shall be determined separately before stranding by means of standard tests on sample wires. The test samples shall be of sufficient length to give an accuracy of atleast one part in a thousand.